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ENVIRONMENTAL EVALUATIONS of PROPOSED DISPOSAL SITES TRACT C-a

Rio Blanco Oil Shale Project

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August 1975

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ABSTRACT

Sixteen alternate spent shale disposal sites for Tract C-a prototype oil shale project were identified. One was on-tract; fifteen were off-tract.

An environmental evaluation was made of these disposal areas to identify sites best suited for this purpose.

The DARE model was chosen to be the vehicle for this evaluation. Nine major criteria containing forty-four minor criteria were identified as important to the decision-making process. These were evaluated by a nine-member expert panel using the literature, input from numerous other professionals, and on-site assessments. A detailed description is presented to enable the reader to follow the procedures in step-wise fashion so that he may use the model.

Four sites were determined to be environmentally superior: Rinky Dink Gulch, 84 Mesa, Dry Fork and Yellow Creek.

I. INTRODUCTION

A. History of the Project

In February 1974, a prototype oil shale lease, Tract C-a, was granted to Gulf Oil Corporation and Standard Oil Co. (Indiana) by the U. S. Department of the Interior. These companies subsequently formed Rio Blanco Oil Shale Project (RBOSP) to operate the tract. The primary purpose of the lease sale was to encourage development of a 5,092.70 acre tract of federally owned land in northwestern Colorado for possible extraction of oil shale by surface or open pit mining methods. Since commercial scale oil shale technology was not available when the lease was granted, the leased tract was designated a "prototype". The purpose of the lease was to allow development of economically feasible oil shale technology.

Development of a prototype open pit mine could continue for 30 years before back-filling could begin. During this period, approximately one billion cubic yards of "spent shale" and enormous amounts of overburden and top soil would be accumulated. Problems arising from disposal of this vast amount of material, and their solutions, are some of the fundamental environmental considerations of the prototype project.

Should open pit mining be employed, storage of spent shale and overburden within the leased tract would not be feasible for several reasons:

1. Overburden and topsoil will be accumulated before the ore is mined.

2. No material can be returned to the mine until the pit floor has been cleared. This could take as much as 30 years from startup.

3. The volume occupied by spent shale and associated moisture will be greater than the volume of shale in place.

4. Waste disposed of on tract would cover oil shale reserves suitable to open pit mining and a second movement of spent shale is not feasible.

Thus, the need for off tract disposal areas is evident.

Determining the location of areas best suited to this purpose is, however,

difficult. The environmental disturbances that will occur are substantial. The effects are complicated by natural limitations to reclamation imposed by this semi-arid region, diverse interests of local ranchers, hunters, industry, and other interested groups, as well as requirements of the lease stipulations. Finding ways to minimize these effects and other questions raised by environmentally concerned citizens prompted the approach toward locating disposal sites discussed in this work.

B. Approach

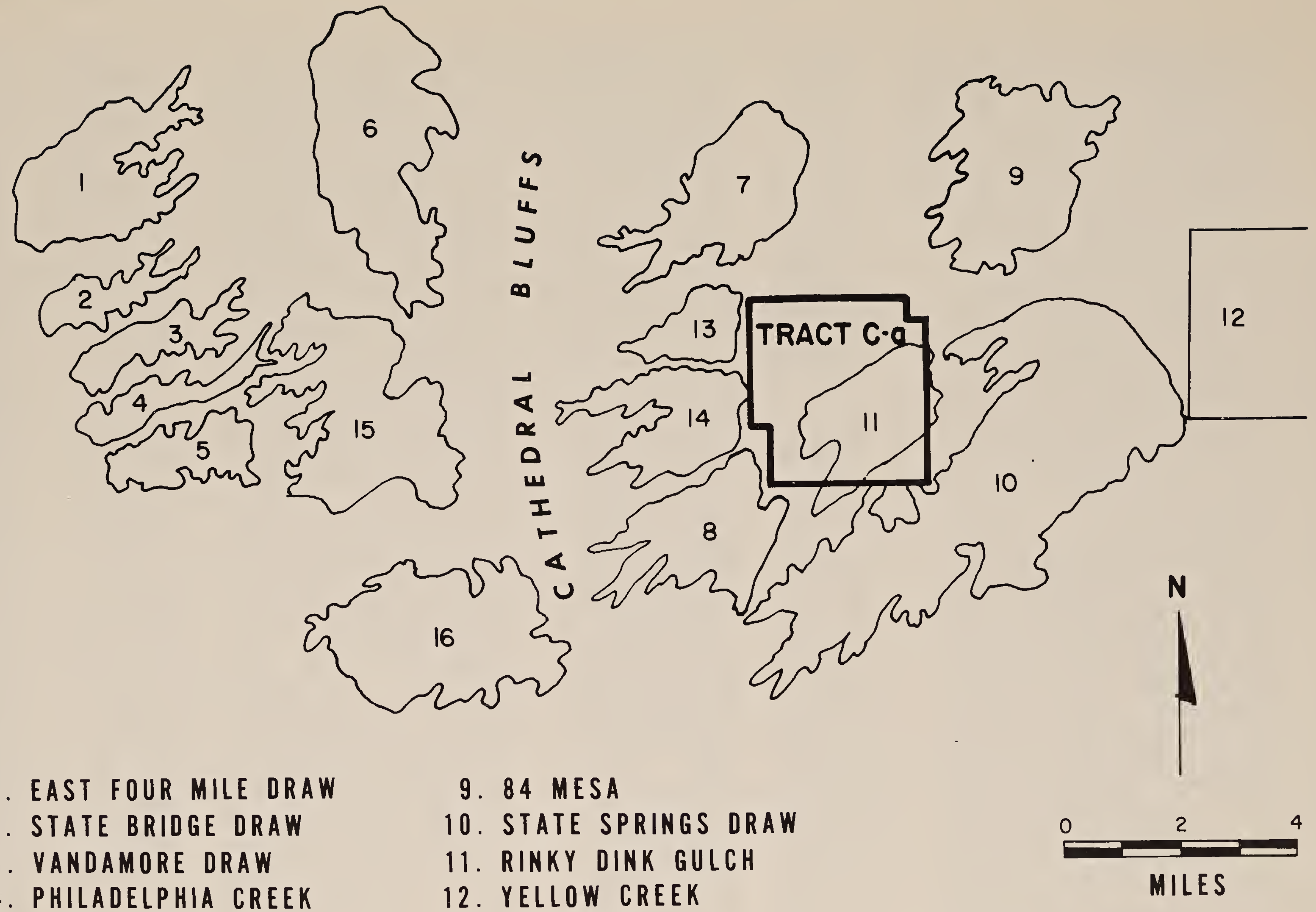
Members of the RBOSP determined that environmental considerations of waste disposal should be considered strictly on their own merits and separated completely from economic and technical (operational) aspects. (Economic and technical specifications were generated independently but are presented elsewhere and are not included in this report).

To provide a basis from which to begin, RBOSP personnel conducted an in-house survey of available information and produced a list of alternate sites. The criteria used for the selection of these areas were:

1. Reasonable proximity to the lease area,
2. Physical possibility for employment as disposal sites,
3. Use of these disposal sites would not preclude future development of the area, and
4. Inclusion of sites recommended in prior reports.

Experts from a variety of technical areas were then consulted. Some of these experts subsequently became members of a panel which:

1. Selected a final total of 16 potential disposal sites (Figure 1),
2. Reviewed various approaches available to make the decisions,
3. Determined the need for a decision-making model,
4. Chose the model which was ultimately used,



1. EAST FOUR MILE DRAW
2. STATE BRIDGE DRAW
3. VANDAMORE DRAW
4. PHILADELPHIA CREEK
5. COW CANYON
6. SPRING CREEK
7. BIG DUCK CREEK
8. BOX ELDER GULCH
9. 84 MESA
10. STATE SPRINGS DRAW
11. RINKY DINK GULCH
12. YELLOW CREEK
13. DRY FORK
14. WATER AND CORRAL GULCH
15. ROCKY POINT DRAW
16. BOW MAN CANYON

RBOSP
TRACT C-a
ALTERNATE DISPOSAL SITES

FIGURE 1

5. Developed criteria for use in the model, and

6. Evaluated, analyzed and recommended the decisions discussed in this paper.

The professionals who worked within this panel are listed in Appendix 1. Not all experts consulted were members of the panel. Some were responsible for initial stages of site and criteria selection. These steps were later retraced by the formal panel with similar results. Others critically reviewed drafts of the final document and suggested revisions of content and wording. Names of all persons involved appear in the list of acknowledgements. Members of the panel included experts from the following disciplines: terrestrial biology, chemical engineering, aquatic biology, atmospheric sciences, chemistry and agronomy, systems ecology, limnology, soil mechanics and geology and mining engineering.

After selection of the 16 alternate sites, panel members recommended use of a decision-making model to help quantify the task at hand and reduce the possibilities of bias from totally subjective judgments.

A number of methods have been applied to this type of problem. Most of these approaches are based on the examination of weighted variables generated by a variety of mathematical methods. Some models are non-linear or complex matrix manipulations which become extremely difficult to operate, expecially when the number of variables is large (Leopold, et al., 1971).

The environmental matrix discussed by Leopold, et al. (1971) involves listing of impacts which would result from the proposed action followed by estimating the magnitude and evaluating the importance of each of these effects. The magnitude and importance values are then combined within the matrix in a summary evaluation. The investigator is encouraged to use factual data rather than preference whenever possible to discourage purely subjective opinion. Reasoning, however, is an important element in this method, and must be thoroughly explained in order to describe the results obtained by this type of analysis.

Matrix analysis cannot, therefore, remove the element of subjective opinion from environmental evaluation. It does, however, provide the investigator with a comprehensive reminder of the variety of interactions that are involved.

There are two major disadvantages to the use of matrix analysis. One is that no two elements in any one matrix are directly equatable because

they represent impact on different parts of the environment. Also, a separate matrix must be prepared for all alternative actions (in this case 16). The elements in each matrix must then be compared to each other to determine preference of one action over another.

The final choice of the panelists was to apply the DARE (Decision Alternative Ration Evaluation) model to the decision requirements in question. Several factors were considered in selecting DARE:

1. It is a linear model and is relatively easy to use,
2. It is easily understood and independently utilized by laymen,
3. It has been used successfully in the past (Vail Pass Alignment Studies and Design Concepts, 1972; Milhollin, 1974), and
4. It was adaptable to the problem under consideration.

In the following sections of this report, the DARE model will be described and the methods by which it was adapted to, and used in, evaluation of the alternative disposal sites for Tract C-a will be explained. Frequent reference will be made to sample tables and computations in order to enable the reader to grasp the principles and apply the model. Section II describes the mathematics of the model. Section III discusses the application of the model.

II. DESCRIPTION OF THE DARE MODEL

The basic assumption of DARE is that the subjective values built into the system are as reliable as the professional(s) making the judgments. It is assumed that decisions will vary among experts, but that the same expert consistently will make similar decisions (Klee, 1970).

The backbone of the model is selection of the criteria for considerations (see Section III). These criteria are developed by expert consensus. They should adequately cover all areas of consideration with minimum subject overlap. It is assumed that it is sometimes desirable to separate major criteria into smaller components and consider the weighted value of each component since all components are not of equal importance to the decision. An example of environmental criteria which would be considered is:

Habitat and Animal Use

- Mixed Brush
- Aspen
- Pinyon-Juniper

"Habitat and Animal Use" is a major criterion to be considered. "Mixed Brush", "Aspen" and "Pinyon-Juniper" are types of habitat, each with varying degrees of importance to the overall habitat quality of a given area. In order to reach a decision about the environmental value of an area, one must consider the relative importance of that habitat, compared with other criteria, to the overall environmental system, and also must consider the relative importance of the components of the habitat to each other.

The DARE system is a series of comparisons; the comparisons of major criteria to one another, and the comparisons of the components of each criterion to each other. The method of comparing criteria is simplified by limiting the comparisons to "pairs of criteria." For example, in Table 1, the criteria are arranged in arbitrary order. Then the following steps are carried out:

1. Criterion 1 (Rehabilitation) is compared to Criterion 2 (Air Quality) for relative importance. Rehabilitation is judged to be 5 times as important as Air Quality. It is assigned the value 5.0 (Column A). Air Quality is judged to be 3 times as important as the next criterion (Noise Impact). It is, therefore, assigned a value of 3.0.

TABLE 1. SAMPLE OF DARE METHOD

	CRITERIA	A	B	C
1.	Rehabilitation	5.0	1.620	22.6
2.	Air Quality	3.0	0.324	4.5
3.	Noise Impact	0.2	0.108	1.5
4.	Unique Aspects	3.0	0.540	7.5
5.	Erosion	2.0	0.180	2.5
6.	Water Quality	0.3	0.090	1.3
7.	Scenic and Recreational Potential	0.1	0.300	4.2
8.	Habitat and Animal Use	3.0	3.000	41.9
9.	Contingencies	0	1.000	14.0
		Sum =	7.162	100.0

$$C = \frac{B}{\text{sum of B}} \times 100$$

e.g.

$$C = \frac{1.620}{7.162} \times 100 = 22.6\%$$

Comparison of pairs continues in this manner down the table until all criteria have been assigned a value. The last criterion has a value of zero, since there are no other criteria for comparison. (Assignment of A column values in Step 1 completes the decision process. The following steps are routine mathematical calculations).

2. Column B is then derived. The last criterion (Contingencies) is assigned the value of 1.000 for the B column (Table 1). Then the evaluator moves up the table in a zig-zag fashion as shown, deriving for each succeeding criterion, a B value by multiplying the B value of the lower criterion by the A value of the criterion immediately above it (e.g., B = 1.000 for contingencies, A = 3.000 for habitat and animal use. The B value for habitat is equal to 1.000 x 3.0 or 3.000). This process continues until all B values have been determined for all criteria. Column B values represent a raw ranking order. They are not useful until they have been normalized to a base of 100. This is done in Step 3.

3. Column C values are obtained by dividing each of the values in Column B by the sum of Column B and multiplying by 100 as shown. The values expressed in Column C represent the relative contribution of each criterion to the whole in percent.

In the values just obtained, the order in which the criteria were arranged will not significantly affect the values (cf. Section III). This evaluation can easily be repeated a number of times by several experts for comparison of results.

The purpose of this procedure is to develop Column C values for all criteria under consideration. The criteria are then ranked by importance and a decision is made.

A shortcoming of the DARE system is that it compares preselected alternatives to one another. It cannot determine what the alternatives should be, or whether they are good or bad. Care is essential, therefore, in choosing alternatives so that they are complete and exhaustive on the one hand, but with minimum overlap on the other hand.

III. THE APPLICATION OF DARE TO RBOSP DISPOSAL SITES

The DARE system as applied to the problem addressed in this report is best discussed in terms of its three basic components:

1. Criteria selection by expert panel,
2. Pair-wise decision process, and
3. Results of the decision ranking.

A. Generation of criteria for evaluation

As mentioned in Section I, a diverse panel of experts was assembled to participate in the decision making process. Once determination of the model to be used had been reached, the next step was selection of criteria for evaluation. To reiterate, this phase of the process is extremely important to the proper functioning of the DARE system. All areas must be addressed with minimum overlap; serious overlap among factors would result in biasing the decision by over-emphasis of components.

All environmental variables likely to be affected by waste disposal were included and all environmental concerns specifically referred to in the oil shale lease (i.e., damage to fish and wildlife habitat, loss of archaeological artifacts, air pollution, water pollution, erosion, revegetation and effects on scenic values) were addressed. The list of criteria was generated originally by the informal panel of experts referred to in Section I. This list was later revised by the formal panel listed in Appendix 1.

Criteria Selection. Selection of criteria followed a series of meetings where the experts carefully weighed all prospective factors. Eventually, panel consensus resulted in selection of nine major criteria, referred to hereafter as categories. These included the following:

Habitat and Animal Use

Rehabilitation

Air Quality

Water Quality

Erosion Potential

Unique Aspects

Scenic and Recreational Potential

Contingencies

Noise Potential

Each of the categories listed above was then sub-divided into its individual components (sub-categories). The same rules of selection applied. Appendix 2 lists all major categories and sub-categories.

Value Assignment. Development of the list of categories and sub-categories previously mentioned was through expert consensus. Assignment of the relative values to each (Appendix 2) followed the DARE method (Section II).

The DARE model provides for arranging the categories to be considered in an arbitrary fashion and then comparing them by pairs in order of arrangement (Section II). This raises the question of possible bias due to arrangement of categories. In order to avoid this possible source of bias, the following steps were undertaken:

1. The nine categories were arranged in 20 different ways by use of a random numbers computer program.
2. Each of the 20 arrangements was analyzed by each of the nine panelists and "A" column values were derived for each analysis.
3. The results of the panelists' evaluations were combined and Column C values were generated in the manner discussed earlier (Table 1, Section II). A simple mean of the values for all 20 arrangements was then determined (Table 2).
4. This mean was selected for use as the weighted value of the category and was used in all future calculations.

Similar methods were used to develop values for sub-categories (Appendix 3). However, it is apparent that not all members of the panel are qualified to judge all categories. Therefore, once rating of categories was complete, rating of sub-categories was limited to panelists with professional expertise in that area as indicated in Appendix 1 (numbers of randomly arranged lists were limited to numbers of possible combinations up to a maximum of 20).

TABLE 2

ENVIRONMENTAL VALUES

OF

MAJOR CATEGORIES

Percentage for Each Major Category

Run No.	Rehabilitation	Air Qual.	Noise Poten.	Unique Aspects	Erosion Poten.	Water Qual.	Scenic & Rec.	Habitat & Use	Contingencies
1	22.7	9.5	1.9	5.3	10.3	10.5	5.8	27.2	6.6
2	17.7	10.8	2.7	6.4	9.3	15.6	3.5	30.5	3.7
3	25.1	12.7	2.3	5.8	11.6	11.2	5.5	22.0	3.7
4	34.7	10.1	2.0	6.6	10.2	9.3	3.4	20.8	2.9
5	21.3	18.9	2.5	7.3	8.5	12.6	3.9	20.6	4.3
6	21.8	10.7	2.2	6.5	12.7	12.0	4.6	24.1	5.3
7	27.9	10.3	2.5	7.8	10.4	9.7	5.7	21.6	4.1
8	22.6	14.3	2.2	8.6	10.6	8.2	6.3	22.7	4.4
9	24.0	11.7	3.1	8.1	12.1	11.0	4.9	20.4	4.7
10	21.7	11.5	2.1	5.8	10.3	11.7	3.7	28.8	4.3
11	16.9	8.6	2.1	12.9	9.1	8.9	5.9	27.7	7.9
12	13.1	13.8	2.9	9.0	7.9	14.9	4.8	30.1	3.6
13	21.0	12.1	2.3	6.6	11.8	12.5	6.5	22.8	4.5
14	19.9	10.2	3.0	8.1	11.6	10.2	4.8	26.7	5.4
15	18.2	15.6	2.7	6.9	11.7	11.1	4.1	26.6	4.2
16	22.3	12.2	2.3	6.8	11.5	11.3	5.4	23.8	4.4
17	20.7	12.8	1.9	6.2	11.5	11.8	3.9	24.7	6.4
18	21.7	13.6	1.9	8.1	9.2	10.6	4.8	24.6	5.6
19	16.6	11.0	3.3	5.2	10.2	16.9	7.3	25.0	4.6
20	16.9	14.1	2.8	10.6	10.9	13.9	4.5	21.8	4.4
S.D.	4.61	2.39	0.43	1.86	1.28	2.23	1.07	3.14	1.17
Mean	21.34	12.23	2.44	7.43	10.57	11.70	4.97	24.63	4.75
Order	2	3	9	6	5	4	7	1	8

[1] The slight discrepancies encountered when summing across the table are the results of numerous rounding-off steps taken when combining scores. They do not significantly alter the results.

The assignment of these values was made prior to field site assessments by the panelists.

B. Application of selected criteria to site-specific evaluations

The assigned criteria and values, which were discussed in the preceding paragraphs, provided the framework for site-specific evaluations. The criteria specifications for categories and sub-categories (Appendix 4) detailed for the field expert the precise definitions and specifications under which his judgment was to be made. The values assigned each sub-category (Appendix 2) defined the numerical bounds of each decision.

The next step was a review of literature to develop adequate background knowledge of the areas. Papers reviewed are listed in the bibliography. After completion of the literature review, the experts conducted a site-by-site evaluation of all alternate sites following the framework established by criteria specifications (Appendix 4) and value listings (Appendix 2); approaches varied with discipline.

Terrestrial evaluations of the sites were made by two (independent) teams of two terrestrial ecologists each. Descriptive results of their field evaluations are shown in Appendix 5.

Additional evaluations were developed by examination and evaluation of topographic maps, soils surveys, aerial photographs, meteorological and air quality data.

Once these independent evaluations were completed, the scores were combined (summation and derivation of the mean) and numerical values of impacts for alternate sites were listed for each sub-category as shown in Table 3.

A complete listing of impact points for all criteria assessment values appears in Appendix 6. The grand total (Column D) of all these impact points for each site and for each sub-category was then calculated as shown in Table 4. Summation of impact points (Column D) for all sub-categories appears in Appendix 6.

Since these impact points portray the environmental desirability of the site, they are negative points arrayed against the selection of that particular site. The greater the number of impact points, the less desirable is the area as a waste disposal site.

TABLE 3

AN EXAMPLE OF IMPACT POINTS ASSIGNED TO THE HABITAT AND ANIMAL USE CATEGORY

Sub-Categories	Species Diversity	Mixed Brush	Riparian	Shad-Scale	Sagebrush	Aspen	Greasewood	Rabbit-brush	Aquatic	Pinon-Juniper	Douglas Fir	Upland Meadow	Grand Total
Max. No. of Points Possible	11.0	14.1	10.1	3.7	7.9	8.6	4.1	4.0	8.7	12.5	9.3	5.5	
Sites	Number of Points Assigned												
1. Four Mile	11.0	2.0	---	---	2.0	1.0	---	---	9.0	13.0	2.0	---	40
2. Statebridge	11.0	2.0	---	---	2.0	1.0	--	---	9.0	13.0	2.0	---	40
3. Vandamore	11.0	2.0	---	---	2.0	1.0	---	---	9.0	13.0	2.0	---	40
4. Philadelphia	11.0	2.0	---	---	2.0	1.0	---	---	9.0	13.0	2.0	---	40
5. Cow Canyon	10.0	2.0	---	--	2.0	1.0	1.0	---	9.0	13.0	2.0	---	40
6. Spring Creek	1.0	1.0	---	---	1.0	---	--	---	9.0	9.0	5.0	5.0	31
7. Big Duck	1.0	---	--	1.0	2.0	---	2.0	--	1.0	12.0	---	---	19
8. Box Elder	3.0	6.0	---	1.0	7.0	---	---	2.0	1.0	---	---	---	20
9. 84 Mesa	6.0	---	---	---	7.0	---	---	---	2.0	3.0	---	---	18
10. Stake Springs	9.0	12.0	1.0	--	3.0	---	---	--	9.0	10.0	---	---	44
11. Rinky Dink	1.0	---	---	1.0	6.0	---	1.0	---	2.0	1.0	---	---	12
12. Yellow Creek	2.0	---	---	2.0	4.0	---	---	1.0	---	---	---	---	9
13. Dry Fork	1.0	---	---	1.0	7.0	---	---	--	1.0	1.0	---	---	11
14. Water-Corral	11.0	6.0	---	3.0	7.0	---	---	--	---	13.0	---	---	40
15. Rocky Point	10.0	6.0	---	1.0	3.0	1.0	--	---	---	13.0	1.0	1.0	36
16. Bowman Canyon	11.0	6.0	---	1.0	3.0	---	--	-	---	13.0	1.0	--	35

NOTE: --- does not occur.

TABLE 4

CALCULATION OF ENVIRONMENTAL SCORE

For

HABITAT AND ANIMAL USE

	Total Impact Points				Unadjusted Environmental Score
IMPACT ANALYSIS	D	E	F	G	H
Four Mile	40.00	1.00	0.87	3.55	0.87
Statebridge	40.00	1.00	0.87	3.55	0.87
Vandamore	40.00	1.00	0.87	3.55	0.87
Philadelphia	40.00	1.00	0.87	3.55	0.87
Cow Canyon	40.00	0.78	0.87	3.55	0.87
Spring Creek	31.00	0.61	1.13	4.58	1.13
Big Duck	19.00	1.05	1.84	7.47	1.84
Box Elder	20.00	0.90	1.75	7.09	1.74
84 Mesa	18.00	2.44	1.94	7.88	1.94
Stake Springs	44.00	0.27	0.80	3.22	0.79
Rinky Dink	12.00	0.75	2.92	11.82	2.91
Yellow Creek	9.00	1.22	3.89	15.76	3.88
Dry Fork	11.00	3.64	3.18	12.90	3.17
Water-Corral	40.00	0.90	0.88	3.55	0.87
Rocky Point	36.00	0.97	0.97	3.94	0.97
Bowman	35.00	0.00	1.00	4.05	1.00

To reiterate, total impact points (such as those for habitat and animal use) summed from Table 3 provide the entries for Column D values in Table 4. (cf. Appendix 6, lower tables, for complete listings). Column D values are then used to generate Column E values by taking the ratio of each succeeding pair of numbers down the column and become equivalent to Column A values (cf. Table 1, Section II). Table 5 is a comparison matrix of "E values" for all possible pairs of disposal sites, relating the relative value of each site to every other site. Column F values are derived in the same manner as Column B values (cf. Table 1, Section II) i. e., by zig-zag multiplications up the E and F Columns.

Since Column E values result from pair-wise comparison of Column D figures, they no longer represent negative impact points, but, rather, the desirability of one site over another for spent shale disposal. Now, the greater the number, the more desirable the area as a waste disposal site.

Column G values are computed from Column F values in exactly the same way that Column C values were computed from Column B values in Table 1, Section II. Thus, Column F is summed, and each value in the column is divided by the sum and multiplied by 100 to produce a percentage figure in Column G which, therefore, represents weighted percentage values based on site-specific investigations.

Column H is produced by the multiplication of the figures in Column G by the appropriate major category value (e. g., for Four Mile Draw in Table 4, the "G value" of 3. 55 is multiplied by the "C value", derived during earlier computations, of 24. 6% for Habitat and Animal Use to arrive at a "H value" of 0. 87). This procedure is repeated until "H values" are derived for all categories at all sites (Appendix 6). Thus, Column H reflects the adjustment of Column G numbers to account for the the relative values assigned to categories prior to field investigations.

Category weights have now been married to site-specific evaluations to produce numerical "unadjusted" environmental scores. "Unadjusted" is used because the capacity of the sites has not yet been considered. This process is explained later in this paper.

TABLE 5. All Possible Combinations of Column E for Each Potential Disposal Site (D Value in Parentheses)

	Four Mile (40)	State Bridge (40)	Vandamore (40)	Philadelphia (40)	Cow Canyon (40)	Spring Creek (31)	Big Duck (19)	Box Elder (20)	84 Mesa (18)	Stake Springs (44)	Rinky Dink Gulch (12)	Yellow Creek (9)	Dry Fork (11)	Water-Corral (40)	Rocky Point (36)	Bowman (35)
Four Mile (40)	1	1.00	1.00	1.00	1.00	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1.00	1.11	1.14
State Bridge (40)	1.00	1	1.00	1.00	1.00	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1.00	1.11	1.14
Vandamore (40)	1.00	1.00	1	1.00	1.00	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1.00	1.11	1.14
Philadelphia (40)	1.00	1.00	1.00	1	1.00	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1.00	1.11	1.14
Cow Canyon (40)	1.00	1.00	1.00	1.00	1	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1.00	1.11	1.14
Spring Creek (31)	.77	.77	.77	.77	.77	1	1.63	1.55	1.72	.70	2.58	3.44	2.82	.77	.86	.89
Big Duck (19)	.47	.47	.47	.47	.47	.61	1	.95	1.05	.43	1.58	2.11	1.73	.47	.53	.54
Box Elder (20)	.50	.50	.50	.50	.50	.64	1.05	1	1.11	.45	1.67	2.22	1.82	.50	.55	.57
84 Mesa (18)	.45	.45	.45	.45	.45	.58	.95	.90	1	.41	1.50	2.00	1.64	.45	.50	.51
Stake Springs (44)	1.10	1.10	1.10	1.10	1.10	1.42	2.32	2.20	2.44	1	3.67	4.89	4.00	1.10	1.22	1.26
Rinky Dink Gulch (12)	.30	.30	.30	.30	.30	.39	.63	.60	.67	.27	1	1.33	1.09	.30	.33	.34
Yellow Creek (9)	.22	.22	.22	.22	.22	.29	.47	.45	.50	.20	.75	1	.82	.22	.25	.26
Dry Fork (11)	.27	.27	.27	.27	.27	.35	.58	.55	.61	.25	.92	1.22	1	.27	.31	.31
Water-Corral (40)	1.00	1.00	1.00	1.00	1.00	1.29	2.10	2.00	2.22	.91	3.33	4.44	3.64	1	1.11	1.14
Rocky Point (36)	.90	.90	.90	.90	.90	1.16	1.89	1.80	2.00	.82	3.00	4.00	3.27	.90	1	1.03
Bowman (35)	.87	.87	.87	.87	.87	1.13	1.84	1.75	1.94	.79	2.92	3.89	3.18	.87	.97	1

C. Results of decision ranking

Unadjusted environmental ranking. "Unadjusted H values" obtained for each of the nine categories can be summed for each site to produce a "total unadjusted H value" which represents, by use of a single number, an environmental evaluation unique to that particular area. Environmental scores (unadjusted H values) for each of the nine categories for each of the sixteen disposal sites are listed in Table 6, as well as the total environmental score (total unadjusted H value) for each site.

To determine statistically significant differences which may, or may not, exist, a studentized Newman-Kuels multiple range test was performed on the total environmental scores (cf. Appendix 7 for details). The sixteen disposal areas were found to fall into four groups on the basis of significant differences between their total environmental scores.

Group I	1.	Rinky Dink Gulch	9.7
	2.	84 Mesa	9.4
	3.	Dry Fork	9.4
	4.	Yellow Creek	8.9
Group II	5.	Big Duck Creek	7.1
	6.	Box Elder Gulch	6.9
Group III	7.	Rocky Point Draw	5.9
	8.	Stake Springs Draw	5.8
	9.	Water & Corral Gulch	5.4
	10.	Spring Creek	5.3
Group IV	11.	Bowman Canyon	4.5
	12.	Vandamore Draw	4.4
	13.	Philadelphia Creek	4.4
	14.	Cow Canyon	4.4
	15.	Four Mile Draw	4.3
	16.	State Bridge Draw	4.3

Thus, although the total environmental scores of the sites within each group may be numerically different, all sites within a group are statistically similar and can be treated as a unit.

Considerations for volume sufficiency. The number of sites which may be required to hold the total amount of waste is a complicating factor. Increased numbers of areas necessitates increased numbers of roads, conveyor systems, traffic, etc. Smaller sites cannot contain the total volume produced, so a second or even a third site could be needed. To account for this additional disturbance, the total environmental scores

TABLE 6

ENVIRONMENTAL SCORES OF INDIVIDUAL DISPOSAL SITES

(Unadjusted)

		Habitat & Use	Rehabilitation	Air Quality	Water Quality	Erosion Potential	Unique Aspects	Scenic and Recreation	Contingencies	Noise Potential	Total Environmental Score	Grouping
1.	Fourmile Draw	0.87	0.89	0.71	0.48	0.57	0.25	0.26	0.21	0.08	4.3	IV
2.	State Bridge Draw	0.87	0.89	0.71	0.50	0.57	0.25	0.26	0.20	0.08	4.3	IV
3.	Vandamore Draw	0.87	0.90	0.71	0.52	0.59	0.25	0.26	0.21	0.08	4.4	IV
4.	Philadelphia Creek	0.87	0.97	0.71	0.52	0.56	0.25	0.26	0.21	0.08	4.4	IV
5.	Cow Canyon	0.87	0.93	0.71	0.51	0.56	0.25	0.26	0.21	0.08	4.4	IV
6.	Spring Creek	1.13	1.46	0.74	0.47	0.62	0.28	0.28	0.21	0.08	5.3	III
7.	Big Duck Creek	1.84	1.62	0.74	1.08	0.87	0.34	0.32	0.25	0.09	7.1	II
8.	Box Elder Gulch	1.74	1.87	0.81	0.93	0.56	0.27	0.30	0.33	0.11	6.9	II
9.	84 Mesa	1.94	1.99	0.81	1.12	1.27	1.27	0.44	0.43	0.14	9.4	I
10.	Stake Springs Draw	0.79	1.97	0.81	0.52	0.57	0.24	0.35	0.46	0.08	5.8	III
11.	Rinky Dink Gulch	2.91	2.20	0.81	0.88	0.59	1.27	0.51	0.42	0.14	9.7	I
12.	Yellow Creek	3.88	1.01	0.81	0.83	0.70	0.34	0.35	0.33	0.08	8.9	I
13.	Dry Fork	3.17	1.17	0.81	1.42	0.78	1.27	0.34	0.39	0.09	9.4	I
14.	Water & Corral Gulch	0.87	1.22	0.81	0.86	1.57	0.29	0.30	0.39	0.09	5.4	III
15.	Rocky Point Draw	0.97	1.07	0.81	0.54	0.61	0.30	0.27	0.23	1.14	5.9	III
16.	Bowman Canyon	1.00	1.05	0.77	0.52	0.62	0.27	0.27	0.23	0.08	4.5	IV

have to be "adjusted" downward. "Sufficiency ratings" were developed from the exponential equation, $f = 1 - (0.33 \log n)$ where n is the number of disposal sites required to provide the adjustment:

Number of Areas Required	Multiplication Factor
1	1.00
2	0.90
3	0.84
4	0.80

The capacity of each disposal site is shown in Table 7.

The way these factors are used can be illustrated by a specific case. If a 55,000 bbl/day shale oil operation is employed using an open pit mine, and if no on-tract disposal is considered (assuming the entire tract can be mined by open pit methods), a single disposal site or some combination of sites must last for 30 years. Using all combinations of from one to three sites, six combinations can be computed and compared to three areas that are sufficiently large by themselves. Ranked in order of "adjusted environmental scores", these are shown in Table 8.

TABLE 7

VOLUMES AND SURFACE CHARACTERISTICS OF DISPOSAL SITES*

Name	Volume cyx 10^6	Average Slope	Area $Ft^2 \times 10^6$	Surface Elev. (Ft)	Depth (Ft)
1. Four Mile Draw	567	4.2%	113	6,400	650
2. State Bridge Draw	163	4.4%	33	6,400	650
3. Vandemore Draw	210	3.8%	43	6,400	520
4. Philadelphia Creek	262	3.1%	35	6,600	650
5. Cow Canyon	212	4.0%	34	6,400	450
6. Spring Creek	1,300	6.8%	132	7,800	1,000
7. Big Duck Creek	837	3.7%	113	7,400	600
8. Box Elder Gulch	776	3.7%	70	7,800	583 avg.
9. 84 Mesa	1,480	2.0%	159	7,100	617 avg.
10. Stake Springs Draw	2,960	2.0%	400	7,200	600
11. Rinky Dink Gulch	700	3.8%	80	7,200	338 avg.
12. Yellow Creek	608	1.8%	139	6,700	314 avg.
13. Dry Fork	237	5.8%	36	7,600	250 avg.
14. Water and Corral Gulch	525	3.6%	82	7,600	433 avg.
15. Rocky Point Draw	1,076	8.0%	59	8,400	1,800 max.
16. Bowman Canyon	1,577	10.0%	98	8,400	1,600 max.

* Different from figures in RBOSP quarterly Report No. 3 which showed larger volumes. Table 7 figures were estimated using different side slopes than used for Report No. 3. Although these numbers in Table 7 are the best available at this time, some changes may yet occur before the final mining studies are completed for the Detailed Development Plan . These changes do not effect the operation and outcome of the DARE model as presented here.

TABLE 8

COMBINED VALUES OF UP TO THREE AREAS ADJUSTED FOR VOLUME SUFFICIENCY

Order by Adjusted Score	Site(s)	Total Environ. Score	X	Sufficiency Factor	=	Adjusted Score	Combined Adjusted Score
1	84 Mesa	9.4		1.00		9.4	9.4
2	Dry Fork	9.4		0.84		7.90	7.1
	Yellow Creek	8.9		0.84		7.48	
	Big Duck Creek	7.1		0.84		5.96	
3.	Dry Fork	9.4		0.84		7.90	7.1
	Yellow Creek	8.9		0.84		7.48	
	Box Elder Gulch	6.9		0.84		5.80	
4.	Rocky Point Draw	5.9		0.90		5.31	6.7
	Yellow Creek	8.9		0.90		8.01	
5.	Dry Fork	9.4		0.90		8.46	6.6
	Spring Creek	5.3		0.90		4.77	
6.	Box Elder Gulch	6.9		0.90		6.21	6.3
	Big Duck Creek	7.1		0.90		6.39	
7.	Rocky Point Draw	5.9		0.84		4.96	6.3
	Dry Fork	9.4		0.84		7.90	
	Big Duck Creek	7.1		0.84		5.96	
8.	Stake Spr. Draw	5.8		1.00		5.8	5.8
9.	Bowman Canyon	5.8		1.00		5.8	4.5

IV. SUMMARY

Assuming that Tract C-a will be mined by open pit, storage of spent shale will have to be off-tract at least initially. Since it may be 30 years before back-filling of the pit can begin, sites best suited for this purpose must be identified.

Sixteen alternate sites were chosen. A decision was made to judge these sites solely on the basis of environmental considerations.

The DARE model was chosen for use in this environmental evaluation. Nine unique aspects of the environment were identified and further sub-divided. Their relative importances were judged and assigned numerical values. Site inspection scores were generated for the sixteen sites. These two series of values were integrated to produce a numerical ranking of all sixteen sites. In the process of making these numerical evaluations, statistical tests were applied to test bias of listing order and to determine if separation into groups was valid.

Four individual sites which could not be statistically differentiated were found to be environmentally superior for use as disposal sites. These were Rinky Dink Gulch, 84 Mesa, Dry Fork and Yellow Creek.

The use of combinations of disposal sites was investigated by computing a sufficiency factor to correct environmental scores when more than one site would be needed.

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APPENDICES

APPENDIX 1

PANELISTS, AFFILIATION AND AREA OF PARTICIPATION IN EVALUATION

Individual Company & Specialty	Noise	Habitat & Animal Use	Rehabilitation	Air Quality	Unique Species	Erosion Potential	Water Quality	Scenic Values	Contingencies
Dr. Clayton Gist Limnetics - System Ecology	X	X							
Dr. Rodney Harmsworth Limnetics - Limnology	X		X		X	X	X	X	X
Dr. Thomas Ivory III NUS - Aquatic Biology	X				X	X	X	X	
Dr. James States ECI - Terrestrial Biology	X	X	X		X			X	X
Dr. Richard Schwendinger RBOSP-Chemistry & Agr.	X		X	X		X	X	X	X
Dr. Dwayne Nielson M-K - Soil Mechanics & Geology	X		X		X	X	X	X	X
Mr. Ted Borer Cameron-Chemical Eng,	X			X	X			X	X
Mr. Ken Server RBOSP-Mining Eng.	X	X	X	X	X	X	X	X	X
Dr. Clark Musgrove EG&G - Atmospheric Physics	X			X		X			

APPENDIX 2

VALUE LISTINGS OF CATEGORIES AND SUB-CATEGORIES

		Major Categories Weights - Percent	Sub-Category Weights - Percent
A.	HABITAT AND ANIMAL USE	24.6	
1.	Species Diversity		11.0
2.	Mixed Brush		14.1
3.	Riparian		10.1
4.	Shadscale		3.7
5.	Sagebrush		7.9
6.	Aspen		8.6
7.	Greasewood		4.1
8.	Rabbitbrush		4.0
9.	Aquatic		8.7
10.	Pinyon-Juniper		12.5
11.	Douglas Fir		9.3
12.	Upland Meadow		5.5
B.	REHABILITATION	21.2	
1.	Elevation		10.8
2.	Cuts and Fills		10.0
3.	Soil Available		27.1
4.	Exposure		15.7
5.	Surface/Volume		17.0
6.	Average Slope		18.7
C.	AIR QUALITY	12.3	
1.	Human Health		40.9
2.	Animal Health		20.7
3.	Vegetation Impact		15.6
4.	Material Damage		6.2
5.	Residential Value		7.0
6.	Soot and Soiling		3.9
7.	Aesthetics		5.7

APPENDIX 2 Cont.

	Major Categories Weights - Percent	Sub-Category Weights - Percent
D. WATER QUALITY	11.7	
1. Stream Impact		19.2
2. Area Terrain Disturbed		16.2
3. Exposed Slopes		18.6
4. Diversion, Dissipators, etc.		20.1
5. Ground Water Impact		25.9
E. EROSION POTENTIAL	10.6	
1. Erodibility of Soil		66.7
2. 100 Year Flood		33.3
F. UNIQUE ASPECTS	7.4	
1. Archaeology		25.9
2. Animals		40.9
3. Plants		33.2
G. SCENIC AND RECREATION	5.0	
1. Total Topographic Exposure		24.6
2. Aesthetic/Vulnerability		26.3
3. Views and Vistas		19.8
4. Recreational Value		29.3
H. CONTINGENCIES	4.7	
1. Fire Potential		21.9
2. Flood Impact		32.6
3. Leaks and Spills		19.5
4. Mass Failure		26.0
I. NOISE POTENTIAL	2.5	
Judgment Factor		100

TABLE 3-1

ENVIRONMENTAL EVALUATION
FOR
HABITAT AND USE

Percentage of Each Area

Run No.	Species Diversity	Mixed Brush	Riparian	Shadscale	Sagebrush	Aspen	Greasewood	Rabbitbrush	Aquatic	Pinyon Juniper	Douglas Fir	Upland Meadow
1	19.4	14.0	6.6	2.8	6.0	5.7	3.8	3.4	2.1	9.0	13.8	13.5
2	10.5	17.7	2.1	3.0	6.3	7.0	4.0	3.8	5.6	8.8	25.0	6.2
3	10.0	9.1	22.0	5.1	9.4	6.9	4.4	3.9	12.5	11.0	2.8	3.0
4	8.3	9.1	7.4	3.7	7.5	11.6	3.2	6.1	16.0	12.7	6.1	8.2
5	8.1	17.3	7.1	4.1	6.1	12.3	3.8	5.1	10.8	10.6	9.6	5.1
6	11.0	19.2	11.6	3.3	6.6	10.0	3.5	3.3	8.4	14.2	3.8	5.1
7	17.4	13.6	9.1	5.3	10.1	8.4	5.8	4.2	7.1	8.0	5.3	5.6
8	5.8	8.1	23.7	3.4	7.7	8.4	4.2	5.0	14.5	7.1	4.2	7.8
9	19.6	9.8	3.7	5.2	6.2	7.5	4.5	3.4	1.7	15.0	18.5	4.9
10	7.0	36.5	6.6	3.2	6.6	6.4	6.2	2.4	4.8	9.3	8.8	2.3
11	13.3	11.2	14.3	3.4	10.4	5.7	4.3	3.8	14.3	10.1	2.6	6.1
12	15.4	14.5	7.6	2.4	9.0	8.6	3.0	3.7	11.7	10.2	7.3	6.6
13	10.5	13.9	8.4	5.5	9.3	8.6	4.6	4.2	6.8	17.9	4.0	6.3
14	11.2	15.5	6.8	3.5	8.5	10.0	4.6	5.3	12.0	9.5	5.5	7.7
15	11.0	9.7	12.8	3.8	8.3	11.6	6.1	4.6	11.0	8.8	6.0	6.3
16	6.6	17.6	7.6	4.4	6.2	9.5	3.4	3.4	14.4	12.1	10.9	3.8
17	8.6	15.6	16.2	3.4	8.3	12.7	3.4	4.5	2.1	19.3	3.4	2.0
18	11.1	11.7	3.8	4.2	5.9	5.8	4.1	3.3	1.0	9.4	37.9	1.7
19	6.1	13.7	10.5	1.0	5.8	7.9	1.0	1.8	7.8	37.8	4.2	2.4
20	8.1	14.9	14.0	2.9	13.5	7.9	3.5	4.0	9.9	8.9	6.7	5.7
S.D.	4.15	6.45	5.71	1.09	2.00	2.18	1.16	0.99	4.72	6.77	8.79	2.73
Mean	10.95	14.14	10.10	3.68	7.89	8.63	4.07	3.96	8.73	12.50	9.32	5.52
Order	3	1	4	12	8	7	10	11	6	2	5	9

TABLE 3-2

ENVIRONMENTAL EVALUATION FOR REHABILITATION

Run No.	Elevation	Cuts & Fills	Soil Avail.	Exposure	Surface/ Volume	Average Slope
1	13.3	13.2	27.6	17.5	13.5	14.9
2	11.9	11.4	31.5	14.8	16.7	13.6
3	9.9	10.0	26.9	15.6	19.2	18.4
4	10.7	10.4	26.4	16.0	12.6	23.9
5	9.8	11.4	23.7	20.3	15.6	19.1
6	16.2	9.0	31.9	14.7	12.6	15.8
7	12.3	9.8	26.5	18.3	21.2	12.0
8	8.9	7.7	27.0	15.8	17.9	22.8
9	8.9	9.4	25.8	14.4	22.6	18.8
10	10.5	11.9	24.9	15.9	14.7	22.1
11	8.5	8.9	25.0	17.2	13.2	27.2
12	11.2	8.9	30.2	18.6	12.6	17.5
13	10.4	9.4	22.8	16.2	21.4	19.8
14	10.4	9.6	25.5	16.8	20.6	17.1
15	9.0	9.6	30.5	14.0	18.9	17.9
S.D.	2.02	1.41	2.78	2.56	3.53	4.03
Mean	10.79	10.04	27.08	15.74	16.95	18.73
Order	5	6	1	4	3	2

TABLE 3-3
ENVIRONMENTAL EVALUATION
FOR
AIR QUALITY

Run No.	Human Health	Animal Health	Vegetation Impact	Materials Damage	Residential Value	Soot & Soiling	Aesthetics
1	46.2	13.6	16.8	6.4	9.3	3.8	3.9
2	37.5	16.1	24.4	5.5	4.8	5.3	6.5
3	47.7	20.2	13.5	4.3	6.0	3.1	5.2
4	49.5	20.2	12.3	5.2	5.1	3.8	3.9
5	49.1	20.4	13.5	4.5	5.5	3.0	4.0
6	36.2	23.4	14.8	7.4	7.6	4.2	6.3
7	44.6	13.9	13.7	12.7	6.2	3.8	5.1
8	31.6	26.9	16.1	5.9	7.9	4.0	7.5
9	41.0	21.0	15.6	6.5	6.6	4.6	4.7
10	45.6	19.8	14.6	5.1	6.9	4.5	3.5
11	41.6	22.7	17.5	5.4	6.0	3.6	3.1
12	39.8	22.3	16.7	5.9	6.5	4.2	4.6
13	46.4	17.2	16.2	5.4	6.0	3.9	4.9
14	24.0	10.1	24.5	13.3	17.9	5.1	5.0
15	25.3	38.3	16.1	5.3	6.1	3.6	5.2
16	36.0	31.1	13.1	5.5	6.4	3.8	4.1
17	42.3	24.6	13.4	5.6	6.1	4.5	3.5
18	49.3	20.3	13.9	4.6	6.5	2.7	2.7
19	57.2	14.2	10.3	4.5	7.1	3.9	2.9
20	26.4	18.2	15.3	4.4	5.9	3.3	26.5
S.D.	8.90	6.4	3.49	2.46	2.75	.66	5.06
Mean	40.87	20.73	15.62	6.17	7.02	3.94	5.66
Order	1	2	3	5	4	7	6

TABLE 3-4
ENVIRONMENTAL EVALUATION
FOR
WATER QUALITY

Run No.	Steam Encroachment	Area Terrain Disturbed	Exposed Slopes	Diversions, Dissipators, etc.	Ground Water
1	18.9	17.7	21.7	22.7	19.1
2	18.4	16.2	20.5	22.8	22.2
3	20.3	20.4	17.7	19.5	22.1
4	17.9	15.7	19.6	18.9	27.9
5	19.8	17.5	14.7	24.7	23.3
6	21.5	14.9	18.2	19.7	25.6
7	19.3	17.5	23.0	20.3	20.0
8	18.9	15.2	17.4	19.8	28.7
9	20.2	15.9	21.3	17.3	25.3
10	20.3	14.6	17.5	19.9	27.7
11	18.8	15.9	16.7	18.8	30.3
12	19.7	15.4	16.4	21.2	27.3
13	17.6	15.2	17.3	19.9	29.9
14	17.2	15.5	18.9	15.5	32.9
15	19.8	14.9	18.1	20.5	26.7
S.D.	1.16	1.53	2.24	2.23	3.95
Mean	19.24	16.17	18.60	20.10	25.94
Order	3	5	4	2	1

TABLE 3-5

ENVIRONMENTAL EVALUATION FOR SCENIC AND RECREATIONAL VALUES

Run No.	Total Topographic Exposure	Aesthetic/ Vulnerability	Views & Vistas	Recreational Value
1	22.4	25.3	20.6	31.8
2	24.1	26.6	19.2	30.1
3	26.4	25.4	20.6	27.6
4	24.3	25.0	19.8	31.0
5	24.0	29.0	19.1	27.9
6	25.8	25.8	18.1	30.3
7	23.1	26.7	23.0	27.1
8	26.3	24.0	16.9	32.8
9	19.4	24.6	21.1	34.9
10	26.9	24.5	21.1	27.4
11	26.2	30.0	18.6	25.1
12	26.7	28.6	19.2	25.4
S.D.	2.23	1.95	1.62	3.02
Mean	24.63	26.29	19.78	29.28
Order	3	2	4	1

TABLE 3-6

ENVIRONMENTAL EVALUATION FOR CONTINGENCIES

Run No.	Fire Poten.	Flood Impact	Leaks & Spills	Mass Failure
1	22.1	30.8	20.3	26.8
2	21.0	28.8	19.4	30.8
3	22.6	38.2	18.9	20.4
S.D.	.82	4.95	.71	5.25
Mean	21.90	32.60	19.53	26.00
Order	3	1	4	2

ENVIRONMENTAL EVALUATION FOR EROSION

Run No.	Erodibility of Soil	100-yr. Flood
1	66.7	33.3

ENVIRONMENTAL EVALUATION FOR UNIQUE ASPECTS

Run No.	Archaeology	Animals	Plants
1	27.0	42.4	30.6
2	24.8	39.4	35.8
S.D.	1.56	2.12	3.68
Mean	25.9	40.90	33.2
Order	3	1	2

APPENDIX 4

CRITERIA SPECIFICATIONS

Following is a brief description of each of the specific environmental variables considered by the model. The list is limited by the importance and the number of variables that could be considered realistically by the panelists. Many other variables, although unlisted, have been considered by each panelist.

I. Habitat and Animal Use

For this category, each of the subcategories are based on the relative importance of the plants in the area. Consequently, each category is a plant community with the exception of one, which carries the title of aquatic. Animal use is related to type of habitat available.

A. Pinyon-Juniper
These areas contain conspicuous pinyon-pine and juniper (cedar) and also significant portions of sage and possibly some shadscale.

B. Sagebrush
Sagebrush areas contain sagebrush as a dominant plant type. In some cases, a mixture of other small brush may be included, but is of little or no importance.

C. Mixed Brush
Mixed Brush is an area containing some pinyon, juniper and a significant amount of sagebrush, but also contains serviceberry and other tall shrubs.

D. Douglas Fir
Douglas fir is defined as a high forest containing Douglas fir and related substory.

E. Aspen
Aspen are large clones of aspen with associated understory.

F. Rabbitbrush
Rabbitbrush, in this case, is the dominant brush, found mostly at lower elevations in association with sagebrush.

I. Habitat and Animal Use (Cont.)

G. Greasewood

Greasewood habitat is also found in lower elevations where greasewood is the dominant shrub associated with sagebrush.

H. Shadscale (saltbrush)

Shadscale occurs in the saltier regions associated with the shale outcrop area and is usually not associated with other types of brush.

I. Riparian

Riparian habitat is located along streams and is composed of cattails, sedges and rushes and other water-dependent types.

J. Upland Meadow

Upland meadows are grassy, park-like areas found at higher elevations, such as on top of Cathedral Bluffs.

K. Species Diversity (transition zones)

These areas are ecological transition zones where many communities come together. An example is the Douglas fir and aspen mixture.

L. Aquatic

The aquatic habitat occurs in streams and ponds and includes associated plant and animal species.

II. Unique Aspects

A. Plants

Possibility of the occurrence of threatened or endangered plant species.

B. Animals

Possibility of the occurrence of threatened or endangered species of animals.

C. Archaeological and Historical

Probability of a major archaeological or historical site being disturbed by the activity.

III. Rehabilitation

A. Surface-Volume
Surface area and volume of material removed and the result of this on revegetation. Disposal sites with larger volumes and small surface areas are most desirable. The ratio of volume to surface area is used to evaluate these parameters.

B. Cuts and Fills
This item was developed to account for excavation other than pit construction. It is directed specifically at plant site and cuts and fills necessary for construction of conveyor systems.

C. Elevation
This is a parameter to examine the relative altitude of a given activity. Some types of rehabilitation are more difficult to rehabilitate when it is at a high altitude. For other systems it is easier.

D. Average Slopes
This is the average steepness across the site.

E. Potential Revegetation Ease
This is the ease with which one may re-establish plant material on a site. It is a function of many parameters such as the nature of the overburden and the growth medium available to the plants.

F. Soil Availability
The rehabilitation of a mined area will require the replacement of native soil types. This parameter evaluates the amount and type of topsoil available for rehabilitation.

G. Available Water
Available water is a parameter used to assess the difficulty getting water to the area of rehabilitation in order to begin germination and re-establish plant species. Water will not be used to continually irrigate the new planting. It is anticipated that it will be used only in establishment.

H. Exposure
This parameter deals with the aspect of the slope or slopes under consideration. For example, in contrast to a slope with a northeastern exposure, a slope that has a south or southwestern exposure would be more difficult to maintain and grow many plant species. Of course, one of the greatest reasons being water.

III. Rehabilitation (Cont.)

H. Exposure (Cont.)

The southwestern exposure would be much hotter and the available water would tend to evaporate rather quickly.

IV. Contingencies

A. Fire Potential

Fire potential includes all areas where fire may break out and cause environmental damage to, or adjacent to the site. Access to the disposal sites with fire fighting equipment, water availability etc., are included.

B. Flood Impact

Flood impact considers the impact that a flood would have if it occurred in the area. Such items as housing, down-stream distance to permanent dwellings etc., are included herein.

C. Leaks and Spills

The impact that leaks and spills from transporting diesel fuel and gasoline to equipment working on the dump site, spills caused by breakage of conveyor systems and pipelines are included herein.

D. Mass Failure

The environmental impact caused by landslides and mud flows on the dump sites and plant sites are considered here.

V. Scenic and Recreation Potential

A. Total Topographic Exposure

This evaluation is based on the visibility of all of the activities at Tract C-a.

B. The Aesthetic Vulnerability

This variable estimates the visual vulnerability of particular sites due to development.

C. Views and Vista

This item is an evaluation of the effect that plant and spent shale sites will have on specific views and vista.

V. Scenic and Recreation Potential (Cont.)

D. Recreational Values
This evaluates the impact on the existing recreational values of spent shale and plant sites. Big game hunting and outdoor recreation are the principle items considered.

VI. Water Quality

A. Stream Impact
The assumption made for this category was that sites nearest major waterways would have the greatest impact on water quality.

B. Area or Terrain Disturbed
This variable is a function of the total area disturbed.

C. Exposed Slopes Constructed
The assumptions here were that sites having the greatest degree of slope and the greatest southwest facing exposure would have the greatest potential impact.

D. Magnitude of Diversions, Dissipators, Etc.
Diversion methods will be necessary to divert water around dumps. Holding ponds will also be required to hold runoff, etc. from dumps. These will add an environmental impact, as well as add significantly to the engineering problem.

E. Ground Water
The assumption was made that the ground water would flow back into the dewatered area of the mine. This would reduce the impact on ground water quality at the sites near the tract. Sites further away will have more impact on ground water quality.

VII. Erosion Control

A. Hundred-Year Flood
This parameter was calculated utilizing USGS hydro-meteorological methods for calculating flood volume threatening the proposed dump and plant sites.

VII. Erosion Control (Cont.)

B. Erodibility of Surface Material
This parameter is based on visual examination and assessment of the erosion which already exists in the specific areas of proposed activity.

VIII. Noise

Noise is a measure of the effect of sound on wildlife activity. Although sound is measureable, the effect on the habitat is not clearly documented. Noise impact was considered a function of intensity of wildlife activity.

IX. Air Quality

A. Human Health
Human health refers to all effects of air quality on physiological human health problems. Principally, it refers to the effects on the respiratory system, but can also refer to effects on skin, eyes and organs other than the lungs, such as the heart.

B. Animal Health
Animal health refers to all physiological health problems that might be experienced by both domestic and wild animals and specifically how animal health affects man. Generally, the areas of most concern will be the effects on game and livestock. A second consideration would be the effect on rare or endangered species.

C. Vegetation
Vegetation refers to effects on plants or crops and how these effects influence man. We will be concerned with the effects on agricultural yield. We will also be concerned with plant use for beautification.

D. Materials
Materials refer to effects such as corrosion of metals and the deterioration of paint. The effects can be aesthetic, such as the deterioration of house paint, to functional, such as increased rust on machinery.

E. Residential
Residential refers to effects on property values. Decreased property values could result due to unpleasant odors or any of the other six air quality considerations.

VII. Erosion Control (Cont.)

B. Erodibility of Surface Material
This parameter is based on visual examination and assessment of the erosion which already exists in the specific areas of proposed activity.

VIII. Noise

Noise is a measure of the effect of sound on wildlife activity. Although sound is measureable, the effect on the habitat is not clearly documented. Noise impact was considered a function of intensity of wildlife activity.

IX. Air Quality

A. Human Health
Human health refers to all effects of air quality on physiological human health problems. Principally, it refers to the effects on the respiratory system, but can also refer to effects on skin, eyes and organs other than the lungs, such as the heart.

B. Animal Health
Animal health refers to all physiological health problems that might be experienced by both domestic and wild animals and specifically how animal health affects man. Generally, the areas of most concern will be the effects on game and livestock. A second consideration would be the effect on rare or endangered species.

C. Vegetation
Vegetation refers to effects on plants or crops and how these effects influence man. We will be concerned with the effects on agricultural yield. We will also be concerned with plant use for beautification.

D. Materials
Materials refer to effects such as corrosion of metals and the deterioration of paint. The effects can be aesthetic, such as the deterioration of house paint, to functional, such as increased rust on machinery.

E. Residential
Residential refers to effects on property values. Decreased property values could result due to unpleasant odors or any of the other six air quality considerations.

IX. Air Quality (Cont.)

F. Soiling

Soiling refers to the problem created by the need for additional cleaning. It refers to effects which increase maintenance although they do not damage materials. For example, we are concerned with the housewife's problem of having more dust in the house as a result of project activity.

G. Aesthetics

Aesthetics refers principally to problems associated with reduced visibility and the obscuring of vistas. It would also include psychological effects resulting from the degradation of aesthetics. The problem of odors would also be considered here.

APPENDIX 5

SUMMARY OF THE TERRESTRIAL SITE EVALUATIONS

TEAM 1 EVALUATIONS

I. 84 Mesa Areas

84 Mesa can be described in terms of its two major components, sagebrush flats area and pinyon-juniper stands.

A. Sagebrush Flats

Sagebrush are diminutive and scattered. Herbaceous cover is generally good, but small mammal diversity and abundance is probably low because of the sparse cover (i.e. few nesting areas). This area was judged unimportant to large mammals (except feral horses) because of insufficient cover and browse. Feral horses used the area fairly extensively. Numbers and diversity of avifauna, herpetofauna and invertebrates are probably low when compared to other sites. This upland sagebrush was judged to be the least critical for wildlife of all the vegetation types in the area. Potential use for domestic livestock is, however, greater than at any other site.

B. Pinyon-Juniper Stands

The pinyon-juniper stands were generally very mature with infrequent reproduction. In many of these areas, the understory was sparse, composed of sagebrush and forbs. Deadfalls were common and small mammal and invertebrate diversities were moderately high. Large mammal use appeared to be low, probably due to lack of browse. Avifauna diversity was moderately high, but herpetofauna numbers were low. Use by man was apparently low.

In pinyon-juniper areas which were interspersed with Artemesia tridentata (the upper portion of the mesa), the following was found: extensive wildlife use -- well-worn game trails, numerous pellet groups, broken antlers, kitchen middens (indicating a large diversity of squirrels). Signs were abundant which indicated use by porcupines and feral horses.

II. Stake Springs Draw Areas

Four basic types of vegetation are found in this area: pinyon-juniper, sagebrush, riparian and mixed brush. Elevation varies greatly and habitat types vary accordingly.

A. Pinyon-Juniper

The lower area pinyon-juniper stands are generally younger and more dense in Stake Springs Draw than they are on 84 Mesa. Reproduction is moderate and understory forbs are more numerous than on 84 Mesa, but still highly scattered. Small mammal diversity is slightly higher than 84 Mesa (food is more abundant, but nesting areas are more scarce). Browse is limited; therefore, large animal use would also be limited. Diversity and abundance of avifauna, herpetofauna and invertebrates are greater than on 84 Mesa. Livestock grazing is limited.

As altitude becomes greater, the pinyon-juniper stands acquire a greater understory, particularly browse shrubs. Animal diversity is probably greater than at lower elevations or on 84 Mesa. Livestock grazing is more important at the higher elevations.

B. Sagebrush

Sagebrush areas in Stake Springs Draw are of two distinct types: the short, sparse upland sagebrush and the tall, dense valley or bottom type. The upland sagebrush areas are similar to those found on 84 Mesa. Both of these types are found at lower elevations in Stake Springs Draw, but the valley type is more numerous here than at other sites being considered. Small mammal numbers and diversity are high in the dense valley sagebrush type. Birds are numerous, but diversity is not great because of lack of trees. Invertebrates will probably be numerous, herpetofauna only moderately numerous. Forage grasses for livestock are not as abundant as they are on 84 Mesa.

As elevation increases in Stake Springs Draw, the occurrence of valley sagebrush declines and the upland type is found more frequently. Livestock forage is more abundant, but slopes are steeper. However, cattle appeared to be using the area heavily and deer were using it moderately. Deer frequented the sagebrush and ricegrass bottom, sagebrush, saltbrush and pinyon-juniper slopes and pinyon-juniper ridgetops.

II. Stake Springs Draw Areas (Cont.)

C. Riparian

Riparian areas are limited in Stake Springs Draw, but were judged to be of high importance as a habitat type because a number of species (both plants and animals) are restricted to this type of habitat. Potential use by wildlife is high.

D. Mixed Brush

Mixed brush predominates in the upper reaches of Stake Springs Draw. It has a high value as wildlife habitat because of its high shrub diversity and plant density. Animal density and diversity for all groups would probably be greater in this habitat type than in others. It has a high potential for livestock grazing.

III. West - Northwest Areas

All disposal sites associated with areas west and northwest of the tract would be in regions exhibiting much steeper topography than other sites. Steep north slopes are primarily vegetated with mixed brush and scattered pinyon-juniper. Steep south slopes are mostly sagebrush and shadscale with pinyon-juniper on rocky benches.

A. Pinyon-Juniper

The north slope pinyon-juniper stands are generally young, with moderate to heavy reproduction. Understory is relatively dense, composed of forage and browse species. Small mammal abundance and diversity are high, large mammal utilization is good, and numbers of avifauna and invertebrates should be similar to Upper Stake Springs Draw. Few herpetofauna would be expected. Its usefulness for livestock grazing is highest of all those so far discussed.

B. Sagebrush

Bottomland sagebrush occurs in narrow drainage areas and south slopes. These areas are better suited for wildlife use than 84 Mesa, but less suited than Stake Springs Draw. Livestock use is limited.

C. Mixed Brush

Diversity of mixed brush in these areas is not as great as in Stake Springs Draw and animal diversity and abundance would be correspondingly lower. Slopes are also steeper, which limits use by cattle.

III. West - Northwest Areas (Cont.)

D. Shadscale
This type of vegetation is rare and, therefore, important. Ground cover is sparse and plant diversity is low, however, so use by wildlife is limited.

IV. Douglas Creek Area

Steep canyons running east to west characterize Douglas Creek. The steep north slopes are covered by open pinyon-juniper. Other vegetation types found in the area include sagebrush, greasewood and Douglas fir. The topography is highly diverse and the cliffs are attractive to raptors.

A. Pinyon-Juniper
North slopes at lower elevations are covered by pinyon-juniper with dense browse understory. These are highly attractive to a variety of wildlife species. The pinyon-juniper types in the Douglas Creek area have greater wildlife potential than they do in any other area examined.

B. Sagebrush
Sagebrush areas are of limited value to wildlife in Douglas Creek because they are limited to steep, arid south slopes.

C. Greasewood
Greasewood was found in association with shadscale in the valley bottoms of Douglas Creek. Plant species diversity was relatively low and cover was sparse. Its value for wildlife and livestock use is limited.

D. Douglas Fir
No truly representative stands were represented. The Douglas fir stand was almost a monotype with very low ground cover. It would be of little value for wildlife use except for birds and elk. It is a source of timber for man's use.

TEAM 2 EVALUATIONS

I. Four Mile Draw Areas (Left and Right Forks)

These areas showed heavy wildlife use, especially deer and feral horses. The lower portion is heavily used by cattle.

II. Stake Springs Draw Areas

Showed extensive use by livestock in lower portions, specifically deer and feral horses. Vegetation was judged to be similar to that observed by Team 1.

III. Vandamore Draw and Philadelphia Creek

Lower areas showed extensive use by livestock. In the pinyon-juniper type there appears to be heavy winter use by deer, but no spring/summer use. Varmits, squirrels and birds are numerous.

IV. Spring Creek Area

This area is similar to Douglas Creek, with even greater diversity of slopes and aspects and corresponding vegetation. The following vegetation types (in order by relative importance) were observed: mixed brush, pinyon-juniper, Douglas fir, greasewood and sagebrush.

APPENDIX 6

ASSESSMENT VALUES AND IMPACT ANALYSES FOR PROPOSED SITES

TABLE 6-1

HABITAT AND USE CATEGORY

(WEIGHT = 24.6)

Sub-Categories	Species Diversity	Mixed Brush	Riparian	Shad-scale	Sagebrush	Aspen	Grease wood	Rabbit Brush	Aquatic	Pinyon Juniper	Douglas Fir	Upland Meadow
MAX. IMPACT PTS.	11.0	14.1	10.1	3.7	7.9	8.6	4.1	4.0	8.7	12.5	9.3	5.5
1. Four Mile	11.0	2.0	--	--	2.0	1.0	--	--	9.0	13.0	2.0	--
2. Statebridge	11.0	2.0	--	--	2.0	1.0	--	--	9.0	13.0	2.0	--
3. Vandamore	11.0	2.0	--	--	2.0	1.0	--	--	9.0	13.0	2.0	--
4. Philadephia	11.0	2.0	--	--	2.0	1.0	--	--	9.0	13.0	2.0	--
5. Cow Canyon	10.0	2.0	--	--	2.0	1.0	1.0	00	9.0	13.0	2.0	--
6. Spring Creek	1.0	1.0	--	--	1.0	--	--	--	9.0	9.0	5.0	5.0
7. Big Duck	1.0	--	--	1.0	2.0	--	2.0	--	1.0	12.0	--	--
8. Box Elder	3.0	6.0	--	1.0	7.0	--	--	2.0	1.0	--	--	--
9. 84 Mesa	6.0	--	--	--	7.0	--	--	--	2.0	3.0	--	--
10. Stake Springs	9.0	12.0	1.0	--	3.0	--	--	--	9.0	10.0s	--	--
11. Rinky Dink	1.0	--	--	1.0	6.0	--	1.0	--	2.0	1.0	--	--
12. Yellow Creek	2.0	--	--	2.0	4.0	--	--	1.0	--	--	--	--
13. Dry Fork	1.0	--	--	1.0	7.0	--	--	--	1.0	1.0	--	--
14. Water-Corral	11.0	6.0	--	3.0	7.0	--	--	--	--	13.0	--	--
15. Rocky Point	10.0	6.0	--	1.0	3.0	1.0	--	--	--	13.0	1.0	1.0
16. Bowman Canyon	11.0	6.0	--	1.0	3.0	--	--	--	--	13.0	1.0	--

Note: -- indicates no impact.

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	40.00	1.00	0.87	3.55	0.87
Statebirdge	40.00	1.00	0.87	3.55	0.87
Vandamore	40.00	1.00	0.87	3.55	0.87
Philadelphia	40.00	1.00	0.87	3.55	0.87
Cow Canyon	40.00	0.78	0.87	3.55	0.87
Spring Creek	31.00	0.61	1.13	4.58	1.13
Big Duck	19.00	1.05	1.84	7.47	1.84
Box Elder	20.00	0.90	1.75	7.09	1.74
84 Mesa	18.00	2.44	1.94	7.88	1.94
Stake Springs	44.00	0.27	0.80	3.22	0.79
Rinky Dink	12.00	0.75	2.92	11.82	2.91
Yellow Creek	9.00	1.22	3.89	15.76	3.88
Dry Fork	11.00	3.64	3.18	12.90	3.17
Water-Corral	40.00	0.90	0.88	3.55	0.87
Rocky Point	36.00	0.97	0.97	3.94	0.97
Bowman	35.00	0.00	1.00	4.05	1.00

APPENDIX 6 cont.

TABLE 6-2

MAIN GROUP REHABILITATION

WEIGHT 21.2

Sub-Categories	Elevation	Cuts & Fills	Soil Available	Exposure	Surface/volume	Average Slope
MAXIMUM IMPACT PTS.	10.8	10.0	27.1	15.7	17.0	18.7
1. Four Mile Draw	9.0	0	27	14	17	17
2. Statebridge Draw	9.0	0	27	14	17	17
3. Vandamore Draw	9.0	0	26	14	17	17
4. Philadelphia Creek	9.0	0	26	14	11	17
5. Cow Canyon	9.0	0	26	14	14	17
6. Spring Creek	9.1	0	20	8	5	9
7. Big Duck Creek	7.0	0	15	5	12	7
8. Box Elder Gulch	4.0	0	15	7	8	6
9. 84 Mesa	8.6	0	3	14	9	3
10. Stake Springs Draw	9.9	0	4	7	12	5
11. Rinky Dink Gulch	4.0	0	7	5	9	9
12. Yellow Creek	9.0	0	20	13	17	15
13. Dry Fork	8.0	0	18	10	13	15
14. Water & Corral Gulch	8.0	0	14	9	14	16
15. Rocky Point Draw	9.0	0	26	14	4	17
16. Bowman Canyon	9.0	0	26	14	5	17

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	84.00	1.00	0.85	4.19	0.89
Statebridge	84.00	0.99	0.85	4.19	0.89
Vandamore	83.00	0.93	0.86	4.24	0.90
Philadelphia	77.00	1.04	0.92	4.57	0.97
Cow Canyon	80.00	0.64	0.89	4.40	0.93
Spring Creek	51.10	0.90	1.39	6.89	1.46
Big Duck	46.00	0.87	1.54	7.66	1.62
Box Elder	40.00	0.94	1.77	8.80	1.87
84 Mesa	37.60	1.01	1.89	9.37	1.99
Stake Springs	37.90	0.90	1.87	9.29	1.97
Rinky Dink	34.00	2.18	2.09	10.36	2.20
Yellow Creek	74.00	0.86	0.96	4.76	1.01
Dry Fork	64.00	0.95	1.11	5.50	1.17
Water-Corral	61.00	1.15	1.16	5.77	1.22
Rocky Point	70.00	1.01	1.01	5.03	1.07
Bowman	71.00	0.00	1.00	4.96	1.05

APPENDIX 6 cont.

TABLE 6-3

MAIN GROUP AIR QUALITY

WEIGHT 12.3

Sub-Categories	Human Health	Animal Health	Vege. Impact	Mat. Damage	Res. Value	Soot & Soil	Aesthetics
MAXIMUM IMPACT PTS.	40.9	20.7	15.6	6.2	7.0	3.9	5.7
1. Four Mile Draw	5	5	5	3	2	3	1
2. Statebridge Draw	5	5	5	3	2	3	1
3. Vandamore Draw	5	5	5	3	2	3	1
4. Philadelphia Creek	5	5	5	3	2	3	1
5. Cow Canyon	5	5	5	3	2	3	1
6. Spring Creek	4	5	5	2	2	2	3
7. Big Duck Creek	4	5	5	2	2	2	3
8. Box Elder Gulch	3	5	5	1	2	1	4
9. 84 Mesa	3	5	5	1	2	1	4
10. Stake Springs Draw	3	5	5	1	2	1	4
11. Rinky Dink Gulch	3	5	5	1	2	1	4
12. Yellow Creek	3	5	5	1	2	1	4
13. Dry Fork	3	5	5	1	2	1	4
14. Water & Corral Gulch	3	5	5	1	2	1	4
15. Rocky Point Draw	3	5	5	1	2	1	4
16. Bowman Canyon	3	5	5	1	2	1	4

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	24.00	1.00	0.92	5.77	0.71
Statebridge	24.00	1.00	0.92	5.77	0.71
Vandamore	24.00	1.00	0.92	5.77	0.71
Philadelphia	24.00	1.00	0.92	5.77	0.71
Cow Canyon	24.00	0.96	0.92	5.77	0.71
Spring Creek	23.00	1.00	0.96	6.02	0.74
Big Duck	23.00	0.91	0.96	6.02	0.74
Box Elder	21.00	1.00	1.05	6.60	0.81
84 Mesa	21.00	1.00	1.05	6.60	0.81
Stake Springs	21.00	1.00	1.05	6.60	0.81
Rinky Dink	21.00	1.00	1.05	6.60	0.81
Yellow Creek	21.00	1.00	1.05	6.60	0.81
Dry Fork	21.00	1.00	1.05	6.60	0.81
Water-Corral	21.00	1.00	1.05	6.60	0.81
Rocky Point	21.00	1.05	1.05	6.60	0.81
Bowman	22.00	0.00	1.00	6.30	0.77

APPENDIX 6 cont.

TABLE 6-4

MAIN GROUP WATER QUALITY

WEIGHT 11.7

Sub-Categories	Stream Impact	Area Terrain	Exposed Slopes	Diversion	Ground Water
MAXIMUM IMPACT PTS.	19.2	16.2	18.6	20.1	25.9
1. Four Mile Draw	19	5	17	4	23
2. Statebridge Draw	19	1	18	4	23
3. Vandamore Draw	19	2	16	3	23
4. Philadelphia Creek	19	1	15	5	23
5. Cow Canyon	19	1	16	5	23
6. Spring Creek	18	5	18	8	20
7. Big Duck Creek	5	5	10	5	5
8. Box Elder Gulch	2	3	10	15	5
9. 84 Mesa	5	6	5	8	5
10. Stake Springs draw	4	16	5	20	17
11. Rinky Dink Gulch	0	3	10	19	5
12. Yellow Creek	16	6	4	0	13
13. Dry Fork	0	1	15	2	5
14. Water & Corral Gulch	2	3	14	14	5
15. Rocky Point Draw	19	2	17	1	21
16. Bowman Canyon	19	4	19	0	21

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	68.00	0.96	0.93	4.09	0.48
Statebridge	65.00	0.97	0.97	4.28	0.50
Vandamore	63.00	1.00	1.00	4.42	0.52
Philadelphia	63.00	1.02	1.00	4.42	0.52
Cow Canyon	64.00	1.08	0.98	4.35	0.51
Spring Creek	69.00	0.43	0.91	4.03	0.47
Big Duck	30.00	1.17	2.10	9.27	1.08
Box Elder	35.00	0.83	1.80	7.95	0.93
84 Mesa	29.00	2.14	2.17	9.59	1.12
Stake Springs	62.00	0.60	1.02	4.49	0.52
Rinky Dink	37.00	1.05	1.70	7.52	0.88
Yellow Creek	39.00	0.59	1.62	7.13	0.83
Dry Fork	23.00	1.65	2.74	12.10	1.42
Water-Corral	38.00	1.58	1.66	7.32	0.86
Rocky Point	60.00	1.05	1.05	4.64	0.54
Bowman	63.00	0.00	1.00	4.42	0.52

APPENDIX 6 cont.

TABLE 6-5

MAIN GROUP EROSION

WEIGHT 10.6

Sub-Categories	Erodibility of Soil	100 Year Flood
MAXIMUM IMPACT PTS.	66.7	33.3
1. Four Mile Draw	67	6
2. Statebridge Draw	67	7
3. Vandamore Draw	67	4
4. Philadelphia Creek	67	8
5. Cow Canyon	67	8
6. Spring Creek	55	13
7. Big Duck Creek	40	8
8. Box Elder Gulch	50	25
9. 84 Mesa	20	13
10. Stake Springs Draw	40	33
11. Rinky Dink Gulch	40	31
12. Yellow Creek	60	0
13. Dry Fork	50	4
14. Water & Corral Gulch	50	23
15. Rocky Point Draw	67	2
16. Bowman Canyon	67	0

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	73.00	1.01	0.92	5.41	0.57
Statebridge	74.00	0.96	0.91	5.34	0.57
Vandamore	71.00	1.06	0.94	5.56	0.59
Philadelphia	75.00	1.00	0.89	5.27	0.56
Cow Canyon	75.00	0.91	0.89	5.27	0.56
Spring Creek	68.00	0.71	0.99	5.81	0.62
Big Duck	48.00	1.56	1.40	8.23	0.87
Box Elder	75.00	0.44	0.89	5.27	0.56
84 Mesa	33.00	2.21	2.03	11.97	1.27
Stake Springs	73.00	0.97	0.92	5.41	0.57
Rinky Dink	71.00	0.85	0.94	5.56	0.59
Yellow Creek	60.00	0.90	1.12	6.58	0.70
Dry Fork	54.00	1.35	1.24	7.31	0.78
Water-Corral	73.00	0.95	0.92	5.41	0.57
Rocky Point	69.00	0.97	0.97	5.72	0.61
Bowman	67.00	0.00	1.00	5.89	0.62

APPENDIX 6 cont.

TABLE 6-6

MAIN GROUP NOISE POTENTIAL

WEIGHT 2.5

Sub-Categories	Judgment Factor
MAXIMUM IMPACT PTS.	100.0
1. Four Mile Draw	75
2. Statebridge Draw	75
3. Vandamore Draw	75
4. Philadelphia Creek	75
5. Cow Canyon	75
6. Spring Creek	75
7. Big Duck Creek	65
8. Box Elder Gulch	50
9. 84 Mesa	40
10. Stake Springs Draw	75
11. Rinky Dink Gulch	40
12. Yellow Creek	70
13. Dry Fork	60
14. Water & Corral Gulch	60
15. Rocky Point Draw	75
16. Bowman Canyon	75

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	75.00	1.00	1.00	3.03	0.08
Statebridge	75.00	1.00	1.00	3.03	0.08
Vandamore	75.00	1.00	1.00	3.03	0.08
Philadelphia	75.00	1.00	1.00	3.03	0.08
Cow Canyon	75.00	1.00	1.00	3.03	0.08
Spring Creek	75.00	0.87	1.00	3.03	0.08
Big Duck	65.00	0.77	1.15	3.50	0.09
Box Elder	50.00	0.80	1.50	4.55	0.11
84 Mesa	40.00	1.88	1.88	5.69	0.14
Stake Springs	75.00	0.53	1.00	3.03	0.08
Rinky Dink	40.00	1.75	1.88	5.69	0.14
Yellow Creek	70.00	0.86	1.07	3.25	0.08
Dry Fork	60.00	1.00	1.25	3.79	0.09
Water-Corral	60.00	0.08	1.25	3.79	0.09
Rocky Point	5.00	15.00	15.00	45.49	1.14
Bowman	75.00	0.00	1.00	3.03	0.08

TABLE 6-7

MAIN GROUP SCENIC AND RECREATION

WEIGHT 5.0

Sub-Categories	Total Topographic Exp.	Aesthetic	View & Vista	Rec. Value
MAXIMUM IMPACT PTS.	24.6	26.3	19.8	29.3
1. Four Mile Draw	20	20	17	25
2. Statebridge Draw	20	20	17	25
3. Vandamore Draw	20	20	17	25
4. Philadelphia Creek	20	20	17	25
5. Cow Canyon	20	20	17	25
6. Spring Creek	10	26	17	23
7. Big Duck Creek	7	20	17	22
8. Box Elder Gulch	15	20	10	25
9. 84 Mesa	22	10	8	8
10. Stake Springs Draw	15	20	13	12
11. Rinky Dink Gulch	15	12	8	6
12. Yellow Creek	22	12	8	17
13. Dry Fork	15	12	12	23
14. Water & Corral Gulch	15	16	14	25
15. Rocky Point Draw	15	20	17	25
16. Bowman Canyon	15	20	17	25

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	82.00	1.00	0.94	5.11	0.26
Statebridge	82.00	1.00	0.94	5.11	0.26
Vandamore	82.00	1.00	0.94	5.11	0.26
Phildelphia	82.00	1.00	0.94	5.11	0.26
Cow Canyon	82.00	0.93	0.94	5.11	0.26
Spring Creek	76.00	0.87	1.01	5.51	0.28
Big Duck	66.00	1.06	1.17	6.34	0.32
Box Elder	70.00	0.69	1.10	5.98	0.30
84 Mesa	48.00	1.25	1.60	8.72	0.44
Stake Springs	60.00	0.68	1.28	6.98	0.35
Rinky Dink	41.00	1.44	1.88	10.21	0.51
Yellow Creek	59.00	1.05	1.31	7.10	0.35
Dry Fork	62.00	1.13	1.24	6.75	0.34
Water-Corral	70.00	1.10	1.10	5.98	0.30
Rocky Point	77.00	1.00	1.00	5.44	0.27
Bowman	77.00	0.00	1.00	5.44	0.27

TABLE 6-8

MAIN GROUP UNIQUE ASPECTS

WEIGHT 7.4

Sub-Categories	Archaeology	Animals	Plants
MAXIMUM IMPACT PTS.	25.9	40.9	33.2
1. Four Mile Draw	10	35	26
2. Statebridge Draw	10	35	26
3. Vandamore Draw	10	35	26
4. Philadelphia Creek	10	35	26
5. Cow Canyon	10	35	26
6. Spring Creek	10	30	23
7. Big Duck Creek	0	30	23
8. Box Elder Gulch	0	38	28
9. 84 Mesa	0	8	6
10. Stake Springs Draw	10	36	27
11. Rinky Dink Gulch	0	8	6
12. Yellow Creek	10	25	18
13. Dry Fork	0	8	6
14. Water & Corral Gulch	0	35	26
15. Rocky Point Draw	10	28	22
16. Bowman Canyon	10	32	24

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	71.00	1.00	0.93	3.39	0.25
Statebridge	71.00	1.00	0.93	3.39	0.25
Vandamore	71.00	1.00	0.93	3.39	0.25
Philadelphia	71.00	1.00	0.93	3.39	0.25
Cow Canyon	71.00	0.89	0.93	3.39	0.25
Spring Creek	63.00	0.84	1.05	3.82	0.28
Big Duck	53.00	1.25	1.25	4.54	0.34
Box Elders	66.00	0.21	1.00	3.65	0.27
84 Mesa	14.00	5.21	4.71	17.20	1.27
Stake Springs	73.00	0.19	0.90	3.30	0.24
Rinky Dink	14.00	3.79	4.71	17.20	1.27
Yellow Creek	53.00	0.26	1.25	4.54	0.34
Dry Fork	14.00	4.36	4.71	17.20	1.27
Water-Corral	61.00	0.98	1.08	3.95	0.29
Rocky Point	60.00	1.10	1.10	4.01	0.30
Bowman	66.00	0.00	1.00	3.65	0.27

APPENDIX 6 cont.

TABLE 6-9

MAIN GROUP CONTINGENCIES

WEIGHT 4.7

Sub-Categories	Fire Potential	Flood Impact	Leaks & Spills	Mass Failure
MAXIMUM IMPACT PTS.	21.9	32.5	19.5	26.0
1. Four Mile Draw	17	28	18	20
2. Statebridge Draw	17	33	18	20
3. Vandamore Draw	17	28	18	20
4. Philadelphia Creek	17	28	18	20
5. Cow Canyon	17	29	18	20
6. Spring Creek	18	25	18	22
7. Big Duck Creek	13	20	15	22
8. Box Elder Gulch	13	20	4	16
9. 84 Mesa	10	10	10	10
10. Stake Springs Draw	8	10	10	10
11. Rinky Dink Gulch	8	15	6	12
12. Yellow Creek	14	12	17	10
13. Dry Fork	12	15	6	12
14. Water & Corral Gulch	12	15	6	12
15. Rocky Point Draw	17	20	17	20
16. Bowman Canyon	17	20	17	20

IMPACT ANALYSIS	D	E	F	G	H
Four Mile	83.00	1.06	0.89	4.45	0.21
Statebridge	88.00	0.94	0.84	4.20	0.20
Vandamore	83.00	1.00	0.89	4.45	0.21
Philadelphia	83.00	1.01	0.89	4.45	0.21
Cow Canyon	84.00	0.99	0.88	4.40	0.21
Spring Creek	83.00	0.84	0.89	4.45	0.21
Big Duck	70.00	0.76	1.06	5.28	0.25
Box Elder	53.00	0.75	1.40	6.97	0.33
84 Mesa	40.00	0.95	1.85	9.24	0.43
Stake Springs	38.00	1.08	1.95	9.72	0.46
Rinky Dink	41.00	1.29	1.80	9.01	0.42
Yellow Creek	53.00	0.85	1.40	6.97	0.33
Dry Fork	45.00	1.00	1.64	8.21	0.39
Water-Corral	45.00	1.64	1.64	8.21	0.39
Rocky Point	74.00	1.00	1.00	4.99	0.23
Bowman	74.00	0.00	1.00	4.99	0.23

APPENDIX 7

SIGNIFICANCE OF SCORES

A studentized Newman-Keuls multiple-range test was chosen because, although it lacks a certain amount of sensitivity, it provides excellent protection against Type I errors (the probability of rejecting a true null hypothesis); therefore, this type of test should be used in evaluation of various procedures concerning the ability to detect real differences (Kramer and Swanson, 1973).

The multiple-comparison procedure by the Newman-Keuls test considers the null hypothesis $H_o: \mu_a = \mu_b$, where the subscripts denote any possible pair of groups. For K groups, K(K-1)/2, different pairwise comparisons may be made.

The first step in the analysis is to arrange and number all five sample means in order of increasing magnitude, then pairwise difference, $\bar{X}_a - \bar{X}_b$, are tabulated. In this test, values known as "studentized ranges" are utilized, abbreviated q, which are obtained from a studentized range table and are dependent upon the degrees of freedom associated with the standard error; and p, the number of means in the range of means being tested. To compare rank, means u_5 and u_1 for example, the range of 5 means are considered, so p = 5; to test mean 5 versus mean 2, p = 4 and so forth. Just as a difference between means divided by appropriate standard error yields a t value, a q value in the Newman-Keuls test is calculated dividing a difference between means by $SE = \sqrt{s^2/n}$ where s^2 is the variance associated with the parameters being tested and n is the number of observations in groups a and b. If the calculated q value, $a = (\bar{X}_a - \bar{X}_b)/SE$, is equal to or greater than the critical value $q\,\alpha,v,p$, then $H_o: \mu_a - \mu_b$ is rejected. The significance level, α, is the probability of encountering at least one Type I error during the course of comparing all pairs of means. It is not the probability of committing a Type I error for a single comparison.

The conculsions reached by multiple-range testing are dependent upon the order in which the pairwise comparisons are considered. The proper procedure is to compare first the largest against the smallest, then the largest against the smallest and so on until the largest has been compared with the second largest. Then, one compares the second largest with the smallest and the second largest with the next smallest and so on. For example, after ranking five means in descending order, the sequence of comparisons is as follows:

> Means 5 vs. 1, 5 vs. 2, 5 vs. 3, 5 vs. 4, 4 vs. 1, 4 vs. 2, 4 vs. 3, 3 vs. 1, 3 vs. 2, and 2 vs. 1.

Another important rule of procedures is that if no difference is found between two means, then it is concluded that no difference exists between any means enclosed by these two and such differences are not tested for. Thus, in Table D-1, it was concluded no difference exists between Rinky Dink Gulch and Yellow Creek; therefore, no tests are performed to judge the differences between Rinky Dink Gulch and 84 Mesa. Thus, the conclusions in Table 6 are that Rinky Dink Gulch, Dry Fork, 84 Mesa and Yellow Creek are not significantly different; therefore, from a statistical standpoint, probably came from the same population and that Big Duck Creek is significantly different and represents a separate population. Therefore, we can conclude that, from an environmental standpoint, one could select any one of the first four proposed locations as an overburden and spent shale dump site with no significant difference in potential environmental impact.

References cited:

Kramer, S. G. and Swanson, M. R. 1973. An evaluation of ten pairwise multiple comparison procedures by Monte Carlo methods. J. of the Am. Statistical Assoc. 68:66-74.

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, N. J., 620p

Table D-1 Results of Newman-Keuls multiple-range tests on the DARE evaluation of the potential overburden and spent shale dump sites.

Site Comparison	Differences $(\bar{X}_a - \bar{X}_b)$	SE	q	p	$q_{.05,9,p}$	Conclusions
Rinky Dink Gulch vs. Big Duck Creek	2.58	0.28	9.21	5	4.756	Significant difference
Rinky Dink Gulch vs. Yellow Creek	0.80	0.28	2.86	4	4.415	No significant difference
Rinky Dink Gulch vs. 84 Mesa	Not tested					
Rinky Dink Gulch vs. Dry Fork	Not tested					
Dry Fork vs. Big Duck Creek	2.28	0.28	8.14	4	4.415	Significant difference
Dry Fork vs. Yellow Creek	0.50	0.28	1.79	3	3.950	No significant difference
Dry Fork vs. 84 Mesa	Not tested					
84 Mesa vs. Big Duck Creek	2.26	0.28	8.07	3	3.950	Significant difference
84 Mesa vs. Yellow Creek	0.48	0.28	1.71	2	3.199	No significant difference
Yellow Creek vs. Big Duck Creek	1.78	0.28	6.36	2	3.199	Significant difference

Conclusion:

Based on the DARE System Rating, there is no statistically significant environmental difference between Rinky Dink Gulch, Dry Fork, 84 Mesa and Yellow Creek.

Addendum - Literature Review

ADDENDUM

A
BRIEF REVIEW
OF
METHODS USED TO
EVALUATE ENVIRONMENTAL IMPACT

Rosielea Gash

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I. INTRODUCTION

Following passage of the National Environmental Policy Act (NEPA) of 1969 and subsequent legislation, preparation of environmental impact statements for all proposed developments of "Major Federal Significance" has been required. Many environmental impact statements have, unfortunately, been excessively wordy, highly padded and grossly insufficient, especially when defining initial and future environmental impacts.

These insufficiencies have led to efforts on the part of many federal and state agencies, private consultants and industry to develop more efficient and responsive means of assessing environmental impacts.

As a result, a myriad of impact assessments procedures have been devised. Methods vary from simple descriptive checklists to complex matrix comparisons; from use of complex computerized modeling techniques to total loack of modeling. Some identify sources of impact; others go further to predict future impacts and evaluate the total impact of the development to the environmental system.

No attempt is made in this paper to present a comprehensive review of all assessment techniques. A few of the more widely discussed or interesting methods are reviewed to provide basic information related to the complexities of environmental impact assessment and the diversity of approaches that have been suggested.

The review is organized in the following manner: 1) other review papers are discussed with comments on their scope. 2) agency guideline sections which contain suggestions for assessment techniques are reviewed and 3) specific studies and approaches developed either for agencies by private consultants or for specific projects are discussed and limited information regarding application of the method is provided.

II. REVIEW PAPERS

Several good handbooks which discuss methods of impact assessment and evaluation procedures are available. They include: "The Environmental impact Handbook" by Burchell and Listokin (1975); "Managing the Environment" by the U. S. Environmental Protection Agency (1973); and "Environmental Impact Assessment Guidelines and Commentary" by Dickert and Domeny (1974).

Noteworthy papers in Dickert and Domeny (1974) include Biship (1974) and Leopold (1974). Bishop (1974) discusses the uncertainties in evaluation of environmental impacts and proposes consideration of the "safe minimum standard method" to prevent irretrievable loss of environmental benefits. He uses a cost-benefit approach to determine if attainments of a "safe minimum standard" is worth pursuing. Leopold (1974) discusses the purposes of impact statements and the application of matrix-type evaluations to preparation of statements.

An excellent review of approaches toward impact assessment was prepared by Dickert (1974). He classified assessment methods into three types; identification, prediction and evaluation. Identification methods specify range of impacts, describe components of the project and single out elements of the environment that may be affected by the project. Predictive methods can be used to identify significant environmental modifications, to forecast the quantity of these changes and to estimate the probability of the occurence of the change. Evaluation methods are defined as those which will allow determination of how user groups would be affected by the project and those which specify preferred alternatives.

Burchell and Listokin (1975) defined a method of environmental assessment as a means to arrange, present and evaluate the natural, economic, aesthetic, social and cultural effects of a proposed project. They suggested the following hierarchy of assessment methodologies:

1. Multidisciplinary teams
2. Checklists
3. Assessment tables and matrices
4. Mathematical models

In their opinion an assessment analysis should provide for:

1. As much quantification of decision making information as possible,
2. Clear delineation of space and time factors,
3. A set of parameters which characterize impacts at time of construction and later,
4. A minimal means of comparing impacts and
5. A means of identifying and measuring further impacts.

Identification methods discussed by Dickert (1974) included checklists, matrix and network approaches. The State of California, Office of Planning and Research checklist was used as an example. This checklist contained 10 major categories, each of which was further divided into components. The value of the checklist is the focusing of attention on factors which should be considered, the flexibility and the easy-to use summary format (Dickert, 1974). Its major disadvantage is the lack of specificity to individual projects, Dickert (1974) suggested improving the checklist by developing specific checklists for various agency projects.

More sophisticated identification methods discussed by Dickert (1974) include the two-dimensional checklist (matrix) and the network. The matrix is the first step in defining interrelationships of environmental components. Matrices may be cause-effect, component-component or environmental element-environmental element. Matrices are useful for identifying possible ranges of outcomes.

The Leopold et al. (1971) matrix was cited as the "best known cause-effect matrix procedure" (Dickert, 1974). Dickert (1974) was impressed by the simple graphic display of significant effects, but was concerned that this type of analysis precludes consideration of synergistic or secondary effects.

Burchell and Listokin (1975) called the Leopold matrix the most familiar of the matrix approaches. It provides a format of presentation, a scale for numerical weighting and a matrix of existing conditions and actions which could cause impacts. They criticized it however, for omitting the details of how evaluations and weights were derived.

The stepped matrix suggested by J. C. Sorensen in his Coastal Zone Study was cited (Dickert, 1974) as one means of overcoming difficulties related to simple matrix analysis. H. T. Odum's energy diagram method was also mentioned as a variation.

Another approach to impact assessment which is gaining the wide approval of local governments is the McHargion land use suitability map (Burchell and Listokin, 1975). The parameters which will affect land use are mapped on a transparency. Best suited areas (those with fewest overlapping impacts) will appear as light spots on the completed map. Variations of this procedure are computerized mapping and provisions for unequal weighting of parameters.

Predictive methods are probably most difficult to develop both because of deficiency of available data and expertise of impact statement writers. The expense related to the application of these methods is also a contributing factor (Dickert, 1974).

Evaluation type methods are usually applied to the comparison of alternatives (Dickert, 1974). One system developed for this purpose is the environmental evaluation system (EES) developed for the Bureau of Reclamation by Battelle Laboratories (1972). The basic Battelle system and several derivatives are discussed in greater detail later in this paper. Basically it provides for assigning weighted values to a checklist of parameters divided into four categories (ecology, pollution, aesthetics and human interest), and multiplying by environmental quality units to produce a single numerical value. Values of parameters are arrived at by an expert interdisciplinary team along a scale of 100. The resulting numerical value is calculated for alternates and is used for comparison.

The system developed for evaluation of alternative highway alignments in Georgia (Odum et al.,1971) is similar to the Battelle method (Dickert, 1974). The major difference is that it provides for the use of short and long-term weighted values for each of the actual predicted impacts (Dickert, 1974). This method is discussed in greater detail later in this paper.

Dickert's (1974) major criticism of these two methods was the omission of information on how the values were predicted or how disagreements among the experts, if any, were settled. Also, bias reflecting interests of the group cannot be avoided in these studies. Dickert (1974) questioned the use of an aggregrate, or single, index to represent the overall value, since such an index clearly tends to conceal uniquely significant impacts.

The two methods that Burchell and Listokin (1975) cited as being most complete and relatively inexpensive are the Georgia matrix (Odum et al., 1971) and the Battelle Laboratories Method (1972). Of the two, they preferred the Battelle method because it was funded by the Environmental Protection Agency, would probably be more readily accepted and it was adaptable to a wider range of environmental studies.

Dickert (1974) suggested consideration of a method which would combine prediction and evaluation such as the one developed by the Seattle Corps of Engineers. Their procedure uses a repetitive process of making proposals, defending them with factual advantages (pros) and specifying disadvantages of competing alternatives (cons). Participation of local citizens and agencies is encouraged.

The last evaluation method mentioned by Dickert (1974) was the one suggested by the U.S. Atomic Energy Commission (1972). This approach delineates a specific checklist of factors, suggests for each factor the population or resource affected, describes the effect, defines the unit of measure for the impact and suggests methods for computing an indicator for the impact. (The finalized version of this method is discussed in more detail later in this paper).

Although the AEC method doesn't provide for aggregation of impacts, Dickert (1974) stated that it could be combined with the corps of Engineers approach to provide the foundation for the review process.

More complex, and expensive methods are the Ortolano, Isard and Battelle methods (Burchell and Listokin, 1975). The Ortolano study involved 25 experts, who worked for 1 year and developed a conceptual framework for assessing impacts and preparing impact statements. The framework was described as follows:

1. Identification of impacts in relation to time and space.
2. Development of initial forecasts on rule-of-thumb procedures and available information
3. Identification of priorities and research needs, using forecasts as basis for decision.

4. Gathering of information, develop data banks and prepare final forecasts of impacts

5. Integrating final forecasts

Isard's method included the development of an input-output model (Burchell and Listokin, 1975). Battelle Laboratories also developed a "trade-off" model for use in Arizona.

The most comprehensive list of assessment methods appears in the annotated bibliography prepared by Viohl and Mason (1974). Over 75 methods are listed with abstracts of each. Papers listed included complex modeling approaches to those with no modeling and complex matrices to "decreased availability of functions." They suggested comparing methods by (1) kind of technique employed, (2) characteristics of the method and (3) how alternatives are evaluated.

III AGENCY GUIDELINES

Regularly, local, state and national government agencies publish guidelines for preparing impact statements suitable to their specific needs. Requirements to assess impacts of the proposed project and provide recommendations for alternative actions are common to these guidelines. In order to standardize methods of assessment, many guidelines contain suggestions for evaluating impact. The level of detail of course, varies a great deal.

A simple checklist of "factors that could be affected" was provided in the "Guide to Preparation of Environmental Impact Statements (Denver Regional Council of Governments, 1973). The suggestion was made that these factors be rated in the following manner: positive, negative, no effects; minor, moderate and high effects. Alternatives were to be described, with reasons for not using them.

Recommendations for Wisconsin impact evaluation (Kusler and Alston, 1972) included use of a flow chart and a "pool of experts" to select alternates. The Leopold and Battelle methods were described and compared, but neither was considered entirely satisfactory for evaluation of all parameters.

The Pennsylvania Department of Education (1973) published a primer on impact for use by laymen which utilized an instructional flow chart in decision making. The flow chart suggested things to do prior to the decision, provided a group of questions that should be asked, indicated by arrows the direction to proceed and suggested the ranking of solutions from best to poorest. The flowchart was described as a first approximation of the decision process which was neither exceedingly simple nor excessively complex.

A more comprehensive method of evaluating impacts was discussed in the U. S. Nuclear Regulatory Commission (1975) guidelines. This agency, (formerly the Atomic Energy Commission), requires analysis of alternate plant sites on the basis of environmental costs and benefits. The method suggested for evaluating alternate sites involves an initial survey of site availability. In this initial survey, non-feasible areas are eliminated without extensive analysis. Realistic alternates are then mapped and a condensed description of each is prepared, which includes the considerations which led to its selection. Ten areas of consideration were listed as reference in initial selection of sites.

In evaluating each of the alternate sites, the same 10 considerations are used, with greater attention to detail. The analysis is performed for each site by tabular format, showing side-by-side comparisons of alternates.

A paper prepared by Joint Federal, State and Private Organizations Committee (1974) described a detailed procedure for evaluating impact. This study was developed largely for use by fish and game agencies. Ten steps are involved:

1. Establish study guidelines
2. Define responsibilities
3. Specify sub-components and evaluate resources without development
4. Inventory existing resources without development
5. Inventory future resources without development
6. Specify needs, planning objectives
7. Formulate plan for meeting needs
8. Evaluate environmental quality
9. Discuss gains losses, compensation, mitigation, prevention
10. Evaluate monetary costs

Step 8 (the evaluation step) consisted of calculating the net habitat units lost or gained. This is a rather lengthy seven-phase procedure which involves use of transparencies and overlays, estimations of percentage of habitat units lost or gained, graphic comparison of alternates, narrative descriptions of alternates, and comparison of with and without development plans. The result of the study is a voluminous handbook of procedures.

An extravagant plan for environmental assessment is in its formitive stages (Greenfield 1973). This plan sponsored by the EPA and known as the Strategic Environmental Assessment System (SEAS) as envisioned, will:

1. Develop appropriate technology for setting and enforcing pollution control standards

2. Provide a full understanding of environmental impact

3. Provide knowledge of what it costs to meet environmental quality standards

4. Provide knowledge of costs of not meeting standards

5. Perform monitoring to meet environmental goals and

6. Establish a means to forecast long-range effects of societal actions to avoid adverse impacts.

SEAS will imploy a complex mathematical model to aid in assessment of alternates. Much emphasis will be placed on expert opinion.

IV SPECIFIC STUDIES AND APPROACHES

In addition to methods formulated for use by regulatory agencies, a number of consulting firms and academic groups have developed evaluation techniques. These are in some cases funded by governmental agencies and privately developed, others were produced in response to specific projects.

Stover (1972) developed an "Environmental Impact Index" (EII) for evaluating impact. The following steps were to be followed:

1. Gather all available factual information
2. Assemble an interdisciplinary team
3. Determine (by team consenses) environmental functions that will be significantly affected
4. Assign numerical values (team consensus) to the three components (initial impact future impact time) of these functions considering magnitude and significance as shown in the table below.

	Initial Impact (II)	Future Impact (FI)
Extremely beneficial	5	10
Very beneficial	3	6
Beneficial	1	2
No effect	0	0
Detrimental	-1	-2
Very detrimental	-3	-6
Extremely detrimental	-5	-10

Time (T) = number of years area will be impacted

The EII is then calculated by the following formula:

$$\text{EII} = \text{II} \times \text{T (FI)}$$

Stover (1972) used 50 significant environmental functions in the development of his EII.

In analyzing alternates, he suggested use of an "Alternative Proportional Value" (APV). Each alternate is analyzed (judgement) by its estimated impact on each function.

An APV value is derived for each alternate for each function. The alternate judged to impact the function most is assigned a baseline of 1.0. All other alternates are then assigned a value in relation to the baseline.

The APV is then multiplied by the EII for all functions to provide the "Functional Impact Value" (FIV) to be used as a basis of comparison of alternates:

$$FIV = EII \times APV$$

The logic of values assigned to initial and future impact, unfortunately is not explained.

One of the most often cited evaluation methods, as mentioned earlier, is the Leopold Matrix (Leopold et al., 1971). This method was produced by the U. S. Geological Survey in response to a request by Rogers Morton the past Secretary of the Interior. It utilizes an 88 x 100 square matrix of conditions and characteristics of the environment and evaluates points of concern on importance and magnitude on a scale of 1 to 10. Separate matrices must be provided for each alternate. A major criticism is that this method does not provide for any long term effects or allow for synergistic affects.

The Georgia method (Odum et al., 1971) was developed to compare highway alternates. It is a linear combination of 56 component values multiplied by a weighting factor. Data from 22 reports were used by the study group. A mean Impact Index (II) was calculated for each route by scaling the component values to produce commensurate numbers. Both long-and short-term impacts were considered. The impact indexes were determined several times using randomly varying values to help reduce bias of subjective judgments. The decision was then made on the basis of the ranking order of the mean impact values of each alternate.

One of the early Battelle Laboratories methods (Whitman et al., 1971) provided for a 5-man team which selected 66 parameters for use in evaluating impacts.

This study was funded by the Bureau of Reclamation and was designed to evaluate water resources projects. It was published prior to field testing with the recommendation that it be submitted to extensive field testing.

A 12-step procedure was followed which led to a ranking scale for an environmental evaluation system:

1. Extensive review of literature
2. Conceptualization of an interdisciplinary framework for comprehensive, systematic environmental evaluation
3. Field inspection of specific projects
4. Interchange of ideas with agency personnel
5. Development of a detailed framework for evaluating the environmental impacts.
6. Development of a comprehensive list of environmental parameters.
7. Evaluation of each parameter in relation to agency needs
8. Screening of all parameters to achieve consistency
9. Determination of the relative significance of each component under consideration.
10. Development of a weighting or ranking scale for the EES based on relative significance.
11. Determination of conditions of application of the system
12. Determination of research needs

Provision was made for red-flagging areas of unique or special concern.

An updated environmental evaluation system was published by Battelle Laboratories several months later (Dee et al., 1972). It was designed to be "comprehensive, systematic and interdisciplinary". Four major categories (Ecology, environmental pollution, esthetics and human interest) were ranked on the basis of a score of 1000. They were then divided into 18 components, and each component was assigned a relative value from the total assigned to the category to which it belonged. The components were then divided into 78 parameters and assigned relative values or weights (Parameter Importance units - (PIU)

Parameter importance units were derived by combination of a pairwise comparison scaling technique performed by a group of experts with adjustments for unequal numbers of categories, and a feedback repetition process known as the Delphi process (Dalkey, 1969).

For comparison of real data, values must be normalized to make them commensurate. This was done by using available data and obtaining parameter estimates (expressed in real units, e.g. mg/l) and expressing these as a function of 0-1. The resulting value was called the Environmental Quality (EQ).

To mesh these values and obtain the desired Environmental Impact Units (EIU), the following calculation was performed:

$$\text{EIU} = \text{PIU} \times \text{EQ}$$

EIU values were produced to represent the condition with and without the project for all alternates. In addition, this method provided for "red flagging" of especially sensitive areas. Red flags were used when the EQ changed drastically from "without" to "with" development conditions.

The EES was published in a condensed version in an EPA handbook (Battelle Columbus Laboratories, 1972), and recommended for use in water quality management planning.

A variation of the water resources evaluation systems just discussed was prepared by Battelle Laboratories (Reiquam, Dee and Choi, 1974). This method was designed to determine alternative pollution control strategies. A Strategy Effectiveness Index (SEI) was developed in a manner similar to the one used to develop EIU values. The difference in impact which would result if no control was used, compared to the impact inflicted if a control is applied is determined. The SEI is derived for each alternate and SEI values are then compared to find the most effective pollution control strategy.

Another evaluation method worthly of note, which was released by the EPA and stemmed from methods developed earlier by the Battelle Laboratories is the method for predicting future pollution problems (Flinn and Reimers, 1974). This method was developed to identify, rank and project short and intermediate-term future pollution problems. Three independent search approaches were used - industrial production, environmental, and societal trends and activity. An initial list of problems was compiled with the specific stressors of each identified.

Nine ranking factors were devised and the 10 most serious problems were selected and ranked in order of importance. Five-to 10-year projections were then made.

Initially, a set of eight ranking factors was developed, each with a value of 1 to 5 for use in selecting and ranking the 10 most serious problems. These were applied by a team of four professionals to a total of 23 problem statements. Each team member ranked each statement individually. These scores were then arranged in order from highest to lowest. These were assigned numerical values and totalled to produce an overall problem statement score. These problem statements were then recorded and the 10 most serious separated for further consideration. From the 10 most serious, the selection procedure was repeated by an expanded team and an additional ranking factor.

Once the 10 most serious problems had been listed, the ranking factors were assigned relative weights by importance. This was accomplished by the pairwise comparison and feedback of results of nine professionals (socio-psychological scaling and the Delphi method). Weights of the nine ranking factors varied so little, however, that there was little merit in pursuing this approach. The weights were dropped and the factors were given equal weight in assignment of priorities. The final result was a list of the 10 most serious problems in order by importance.

Another scaling technique is the DARE (Decision Alternative Ration Evaluation) method (Klee, 1970). The DARE employs a pairwise comparison technique to rank factors and assign weighted values. The DARE method was discussed in detail in the environmental evaluation procedures and disposal site evaluations section of this paper prepared by Rio Blanco Oil Shale Project. The DARE method is used to elicit responses of experts from a variety of disciplines. As a result of this process values are assigned to various alternates and these are then ranked in order of preference. A major criticism of the DARE method is common to the Battelle methods - use of a single value can conceal many unique aspects of concern.

Many of the papers so far discussed have made reference to the use of the "Delphi Method" as a systematic means of combining the opinions of experts. This method is referred to by Waddell (1974) as applied to determining economic damages of air-pollution.

Essentially, the method is one of subjective decision-making by a pool of experts. For greater detail on this method consult Dalkly (1969) and Pill (1971). Waddell (1974) describes the Delphi method as "an efficient way to produce best judgments where the knowledge and opinion of experts are extracted".

One last method to note is the one by Shugart (in press) which discusses suitability indices for evaluating highway route alternatives. He compares the use of static additive models and dynamic geometric models in developing suitability indices for highways. He found that application of mathematical formulae is not the primarily problem area, but rather, the determination of which variables to consider and in what manner these variables should be scaled.

V SUMMARY

As can easily be seen from this review, the choices of approach to evaluating environmental impact are diverse and are increasing in numbers at a rapid rate. No one method has been universally accepted as the "best approach". It is highly unlikely that any single method will ever be developed that can satisfy all the diverse needs of agencies and industries in determination of impacts. Much emphasis has been placed on comparison of alternatives in response to NEPA requirements that alternatives be considered.

Common to all methods discussed is the heavy reliance on the opinion of experts to evaluate and weight environmental factors in order by importance. The mechanics of the weighting process vary somewhat, but use of a "pairwise comparison technique" has been utilized a great deal.

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